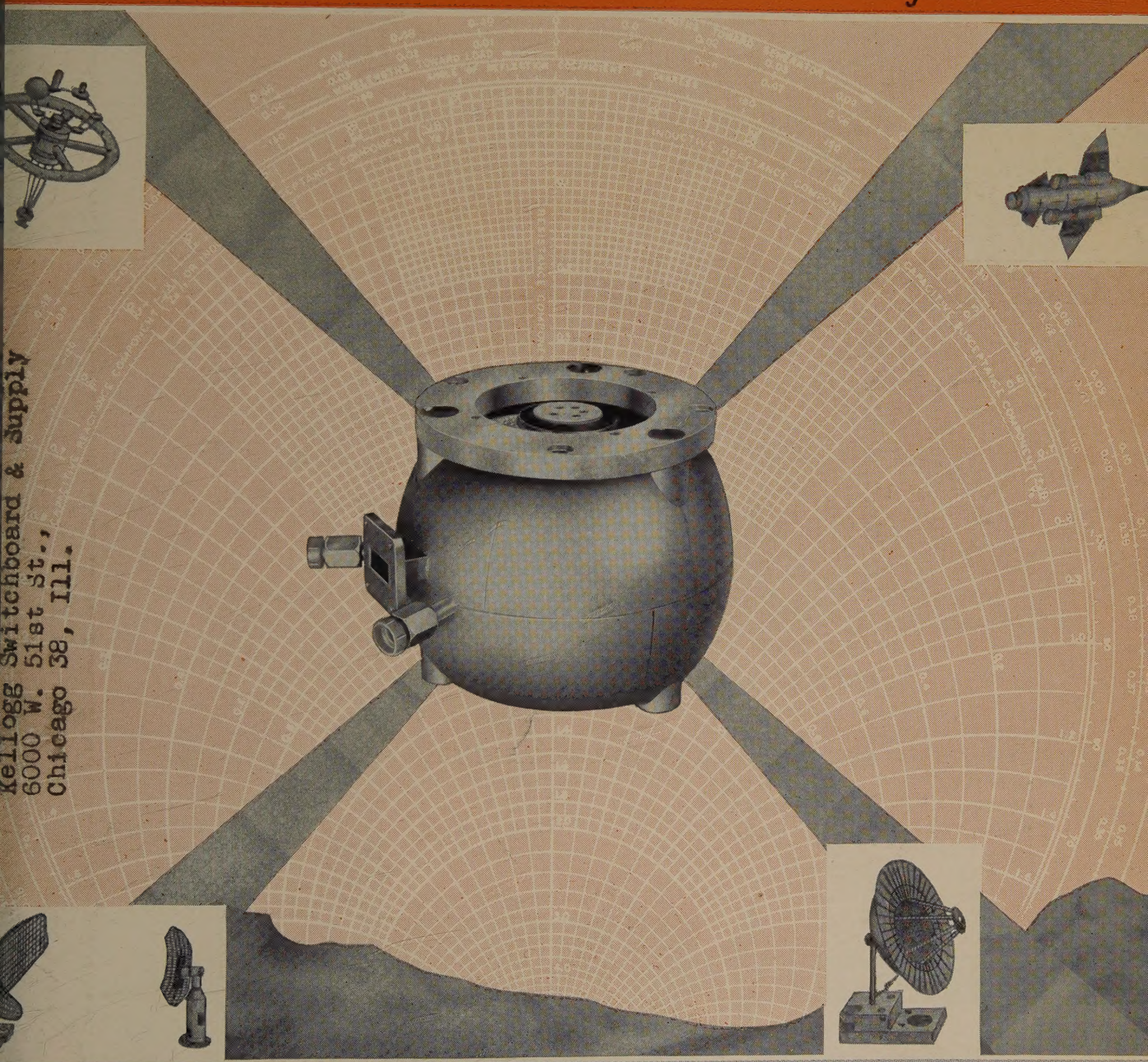
EPTEMBER 1959
OL. 2 • NO. 9

- Paananen—High Power X-Band Backward-Wave Oscillator
- Berland & Vortmeier—Broad-Band Multi-Port Waveguide Switches
- Lamberty—A Novel Aid to Slotted Line Measurements

he microwave journal



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NEXT ISSUE — MONOPULSE SYSTEM PARAMETERS — ANTENNA PATTERN ANALYZER — S-BAND AMPLITRON

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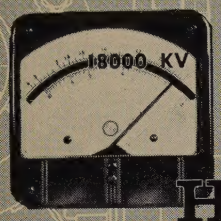

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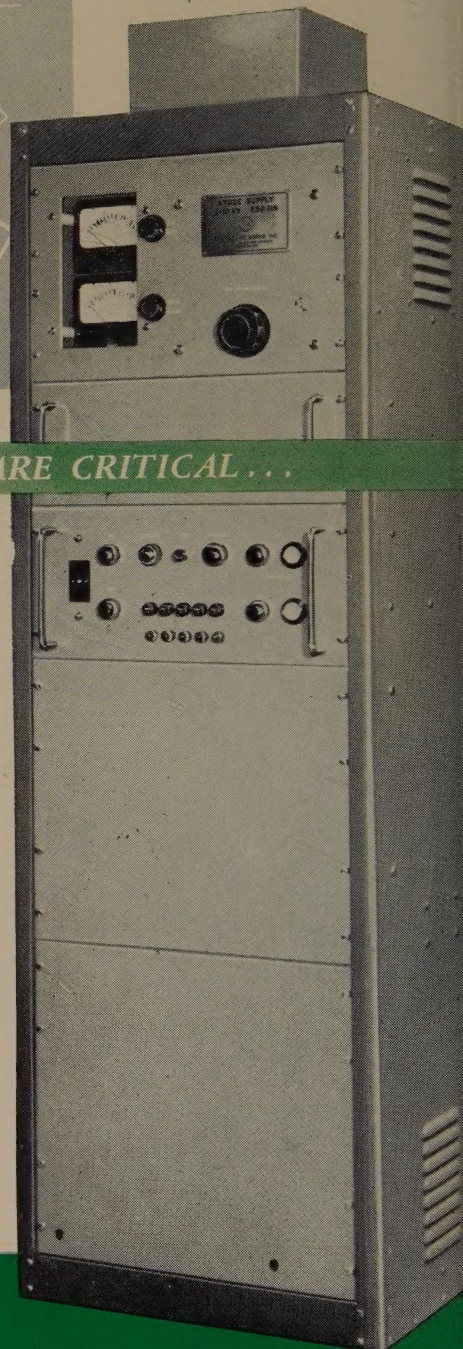

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shown here, FXR Model Z850A

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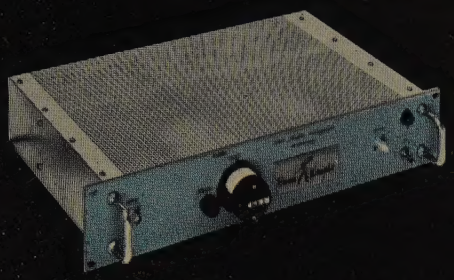
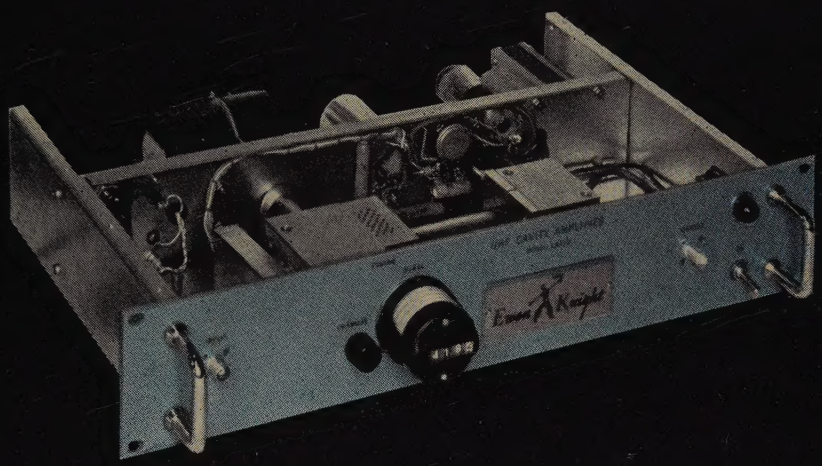
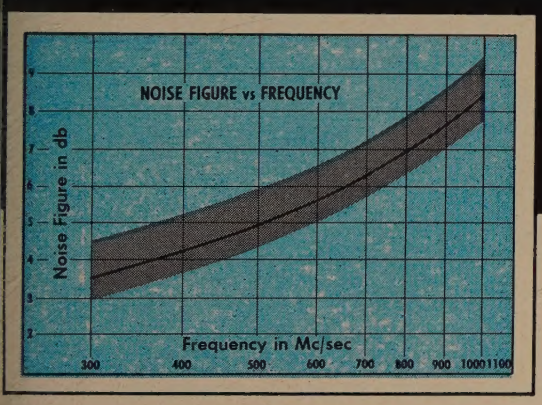


LOW-NOISE UHF CAVITY AMPLIFIER





The Ewen Knight model LNA-T series of amplifiers are ideal for narrow-band applications in the UHF region wherever **low noise is essential.** The four models comprising this series cover the entire frequency range from 300 Mc to 1000 Mc. Rugged, compact and self-contained, each of the LNA-T models mounts on standard 19″ racks and affords easy access to all components, including tube.

SPECIFICATIONS

Noise Figure:	3.5 to 8.5 db (see graph)
Bandwidth:	2% (min.) of f_o
Gain:	10 db (min.)
Panel Size:	3½″ x 19″
Power:	115 V–60 CPS

Tuning Ranges

Model LNA-T4	300 to 450 Mc
LNA-T5	450 to 670 Mc
LNA-T6	500 to 740 Mc
LNA-T8	700 to 1000 Mc

Ewen Knight CORPORATION

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EAST NATICK, MASS.
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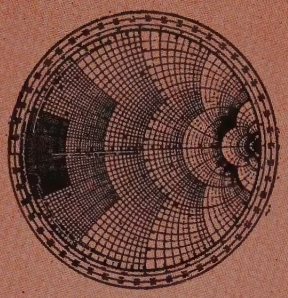
SEPTEMBER, '59 vol.2 - no.9



the microwave journal

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OUR COVER

This cover design is an artistic representation of possible applications for the high-powered backward wave oscillator, a new electron device. As indicated, the characteristics of this tube make it ideally suited for applications such as radar, countermeasures, microwave communications, and telemetering. See page 27.

This design was created by Mr. Paul W. Perry of the Raytheon Company, Waltham, Massachusetts.

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AND CW RADAR

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The highly efficient VA-802 has been designed to meet the rigid demands of both fixed station installations and transportable service. Simple to install and operate, it provides rugged reliability at low operating cost—with power output of 1 Kw, tuning range of 1.7 to 2.4 kMc. Features of this 18″ Klystron with permanent magnet include: Trouble-free internal cavities, low noise and long life.

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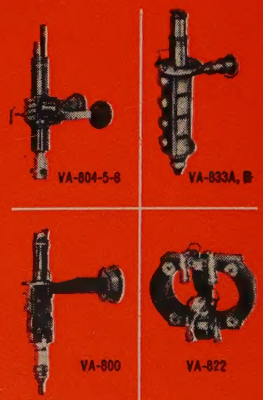

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VA-802	1.7 to 2.4 kMc	1kW cw
VA-804	4.4 to 5.875 kMc	2kW cw
VA-805	5.875 to 6.425 kMc	2kW cw
VA-806	7.125 to 8.5 kMc	2kW cw
VA-822	9.9 to 10.8 kMc	1kW cw
VA-833A, B	.47 to .985 kMc	10kW cw

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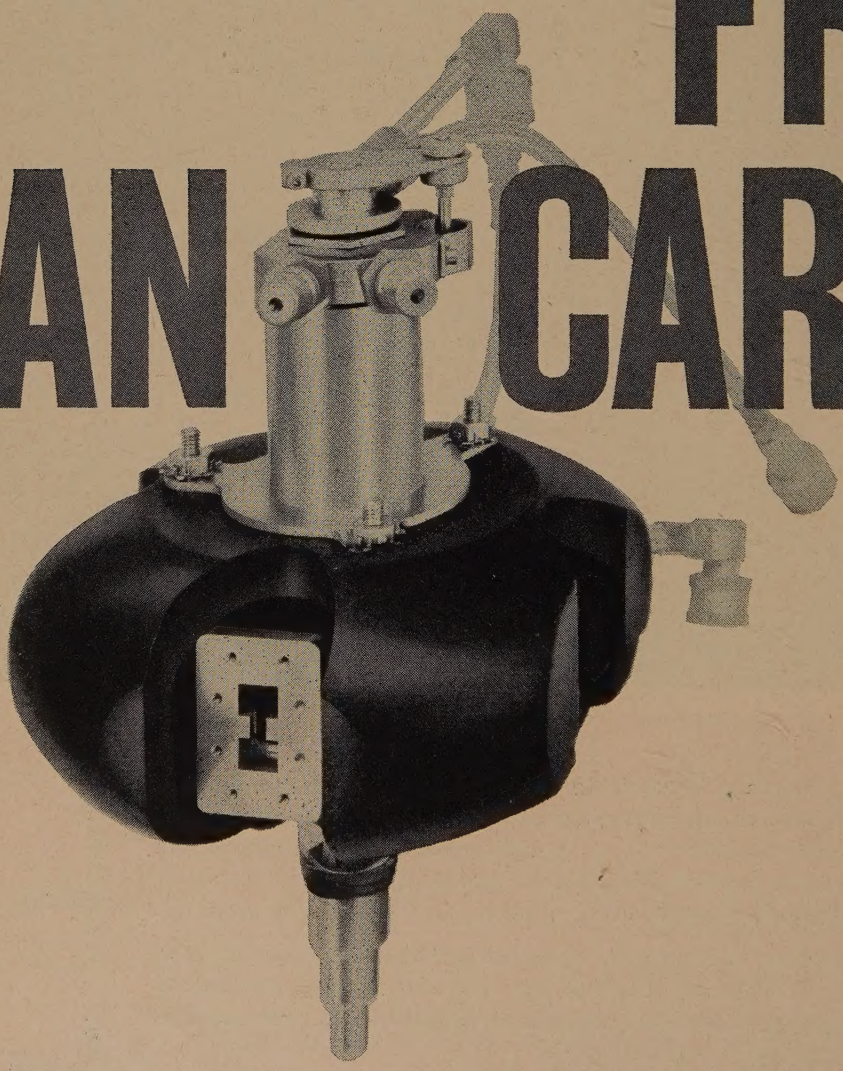
BIG NOISE FROM SAN CARLOS



ARRATRON is a proprietary brand name for proprietary product... our powerful new ECM eapon. It is the electronic industry's newest gh power transmitting tube, a self-modulat- g noise generator. Herein are most of the facts rmitted to be made public. You can (1) ex- apolate from these; (2) if you have a need- -know, send posthaste for our Barratron ochure; (3) come to San Carlos and see for urself a quite amazing generation of white ise. This is *really* big!

We make Barratron tubes in either tunable fixed tuned versions. Both provide broad nd white noise, and both are finding their incipal applications in present and proposed CM jammers.

The tunable version is physically and electri- lly interchangeable with CW magnetrons w installed in obsolescent systems. An added lvantage, beyond the incredible increase in ality of the jamming signal, is that the tun- le version does not require a modulator, and es not require a noise generator chassis. We e conservative when we say that the white ise emanating from a Litton Barratron tube ten times more effective for jamming than e power from a CW magnetron. The tunable arratron tube, then, is designed to upgrade present systems at nominal cost. We are prepared to replace every CW magnetron jammer in existence with this tube.

The fixed tuned Barratron tubes are intended for new systems. They eliminate the need for tuning circuitry or modulators. They are the ultimate in jamming tubes producible at the present time in quantity with reliability. They permit the development of barrage jamming power in systems small enough and light enough for airborne use. They permit truly simultaneous, continuous barraging over any bands you choose; and they permit all this while functioning unattended and automatically.

If you are hesitating because of sophistications you have heard about or have seen in prototype form, hesitate no longer. Those are all deucedly tricky to make, expensive, and everybody has a lot more to learn about them. Meanwhile the Barratron tube is here, ready to cover frequency bands from UHF well into the microwaves and at a cost that is hardly more than a magnetron's.

Our Barratron people will answer any questions you have. Write, or get to the head of the line by sending a telegram. Litton Industries Electron Tube Division, Office M-6, 960 Industrial Road, San Carlos, California.

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FROM THE EDITOR

In the June issue of "the journal," we mentioned some of the abuses of the New Products feature in technical magazines. We received a few comments all in favor of curbing the abuses.

We are anxious to help improve the situation, but before anything is done, we must be careful not to destroy an otherwise useful tool.

One writer felt that the solution of the problem should be left to the editorial staffs of the various trade publications to screen the releases. Another writer suggested that we run statements from time to time, indicating that although we publish the releases we are not necessarily subscribing to the claimed accuracies. This same writer felt that if any of the abuses do come to light and upon investigation we find the manufacturer's claims unjustified, we should refuse to handle further advertisement or allow space for his products in the New Products column.

Another individual wrote saying that he felt "moral pressure should be brought to bear on all manufacturers to give an accurate statement of the specifications their new equipment will meet and to be prepared to back up these specifications."

The response to our June editorial has been by no means overwhelming. On the other hand everyone we have spoken to is in favor of doing something to improve the situation.

Since almost everyone is aware of the problem, this tends to reduce its overall effect. Yet valuable space is being devoted to information which might possibly be put to better use.

"the microwave journal" is young yet, and it may be presumptuous of us to propose a solution. However, it has been suggested that a new feature be added to "the journal." This would be a Certified New Products column. This would operate much as does our present policy; the requirement would be added that those manufacturers who wish to have items appear in this new column would furnish a complete set of specifications plus price and delivery dates, duly signed by a responsible member of the firm. Copies of the signed specifications would be made available to interested parties upon inquiry.

At this point we feel a little like the mouse who was finally talked into belling the cat.

To continue with our campaign we have asked Mr. Bruno Weinschel of Weinschel Engineering, the person who started us thinking about this problem to write an editorial regarding his views on the matter.

The following papers will be featured in our next issue: "Amplitude and Phase Sensing Monopulse System Parameters" (Part I) by W. Cohen and G. M. Steinmetz of Stavid Engineering; "A New Receiver for Antenna Pattern Range" by A. L. Hedrich of Weinschel Engineering and "Simplified Approach to the Design of Bandpass Filters in Waveguide" by Ed Hensperger of Waveline.

Theodore S. Saad

LETTERS

Mr. Theodore Saad, Technical Editor
the microwave journal.
Dear Ted,

I wish to take this opportunity to c
gratulate you on the first anniversary
the microwave journal.

You have done a wonderful job an
have enjoyed reading this magazine.
am sure this publication will beco
even more popular in the years ahe
and I, for one, will be one of your str
boosters.

With best regards.
Cordially yours,
David Ingalls, President
Airtron, Inc.
Division of Litton Industr

• ● •

Editor, *the microwave journal*
Dear Sir:

The following comments are made
connection with Dr. Herbert A. Fink
discussion on "The Conservation of
gineering Talent," June 1959 issue
the Microwave Journal.

I agree with Dr. Finke that the fli
of eminent technical talent into mana
ment is to be deplored and, as he s
there must be a prestige factor wh
equates technical competence to manag
al competence. The solution of this pr
lem is not simple, if at all possible.

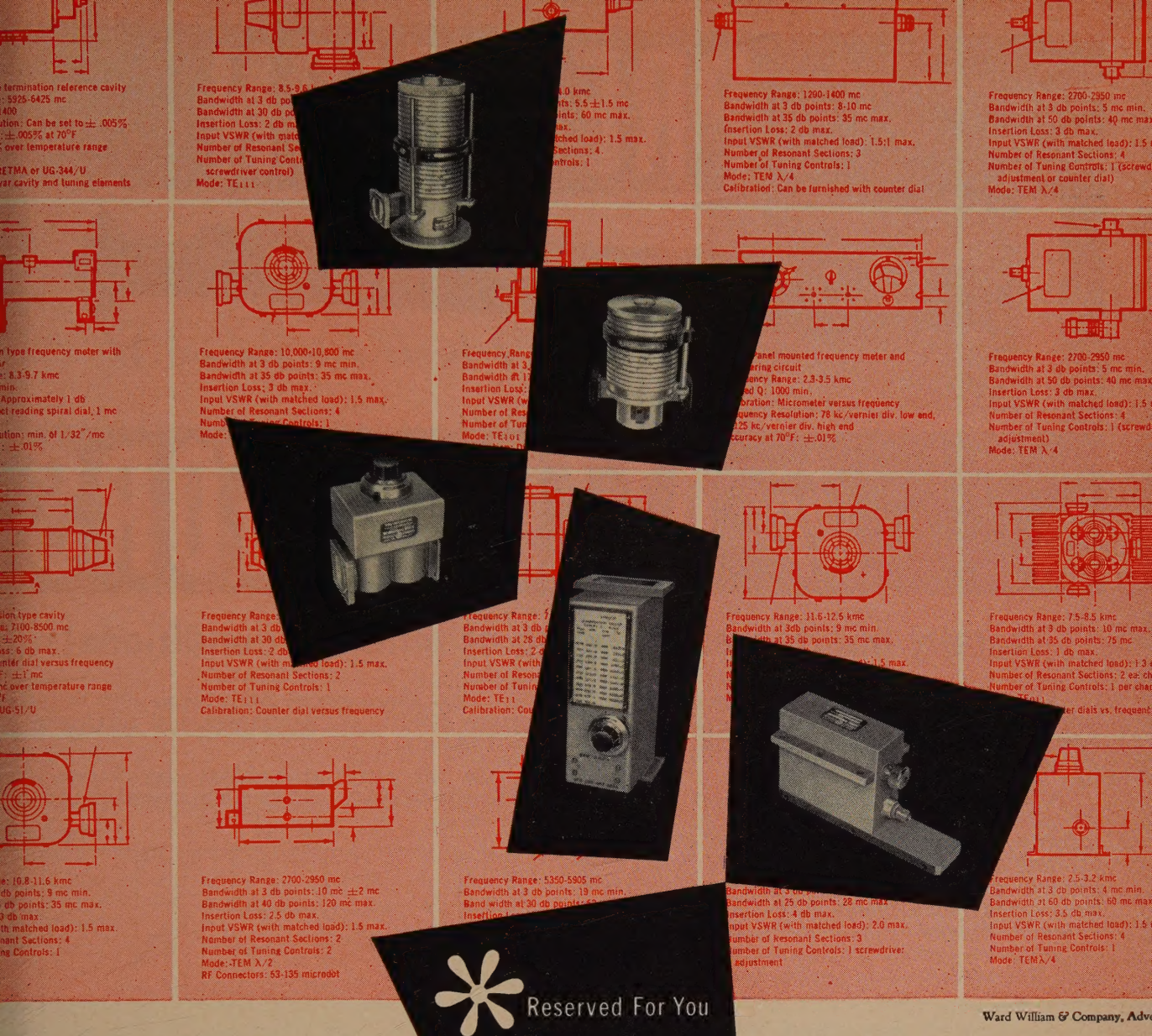
Obvious steps would be to place
engineering functions and names in pa
lel with management on the organizat
chart, and to equate salaries. This
ternal recognition might give some sa
faction, but external prestige still has
be reckoned with.

Some of the problem has to do w
semantics. If the title Engineer, C
Engineer, could be made synonym
with Manager or General Manager, so
of the problem would be solved. But
title Engineer has been degraded beca
of its popularity: everyone wants to
called some kind of an engineer. Ther
a movement now on foot, and is
forced in certain industries, not to ca
man an Engineer unless he is so qu
fied by having passed the State Board
amination and is registered. This
him on a par with the lawyer and ph
cian. A general requirement by indu
that no man can be called an engi
until he can put P. E. after his n
would go a long way toward solving
problem.

Dr. Finke has put his finger on a
tender spot — that of recognition
prestige for Engineering without ha
to desert the profession and go into m
agement.

Yours very sincerely,
Walter J. Seeley,
Duke University
College of Engine

(*Continued on page 18*)



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over 400 microwave frequency meter or filter designs

With hundreds to choose from, you can select the microwave frequency meter or tunable band pass filter to meet your exact requirement. If the unit you need is not already in stock, it can be produced readily by *modifying* one of the Frequency Standards meters or filters now *available*. This means both minimum lead time and development costs. Send your technical requirement for a prompt analysis or meet with our staff to discuss your specific problem.

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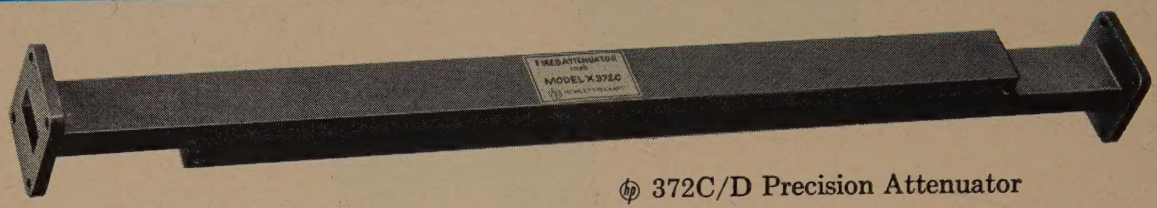

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ATTENUATORS

totally unaffected by aging or ambient conditions!

Aging, humidity, temperature or other ambients — none has any effect on the precise calibration of these ultra-dependable, wideband new attenuators.

Attenuation is inherently invarient because it depends neither on the position of, nor power absorbed by, resistive cards or vanes. Instead, attenuation is a function of the coupling-hole array between two permanently-joined waveguide sections — the same principle as employed in directional couplers. Attenuation accuracy thus achieved averages better than ±0.4 db from nominal, and variation full band is less than ±0.5 db from mean.

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1003C PAGE MILL ROAD · PALO ALTO, CALIFORNIA, U.S.A.
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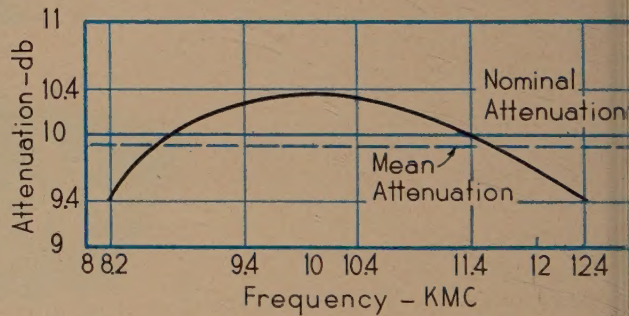
Since there are no protrusions into the wav guide, SWR's are permanent and extremely lo —1.05 to 1.

372 series attenuators are offered in s waveguide sizes, with nominal attenuations of or 20 db.



Typical attenuation characteristics X372C, 10 db model.

SPECIFICATIONS

Model	Freq. (KMC)	Nominal Attenuation	Fits Waveguide Size (in.)	Power (watts ave.)	Price
S372C	2.6 - 3.95	10	3 x 1½	2	$375.00
S372D	2.6 - 3.95	20	3 x 1½	2	375.00
G372C	3.95 - 5.85	10	2 x 1	2	250.00
G372D	3.95 - 5.85	20	2 x 1	2	250.00
J372C	5.85 - 8.2	10	1½ x ¾	1	140.00
J372D	5.85 - 8.2	20	1½ x ¾	1	140.00

Model	Freq. (KMC)	Nominal Attenuation	Fits Waveguide Size (in.)	Power (watts ave.)	Price
H372C	7.05 - 10.0	10	1¼ x ⅝	1	120.00
H372D	7.05 - 10.0	20	1¼ x ⅝	1	120.00
X372C	8.2 - 12.4	10	1 x ½	1	100.00
X372D	8.2 - 12.4	20	1 x ½	1	100.00
P372C	12.4 - 18.0	10	0.702 x 0.391	1	115.00
P372D	12.4 - 18.0	20	0.702 x 0.391	1	115.00

Data subject to change without notice. Prices f.o.b. factory.

pioneers again in better waveguide equipment

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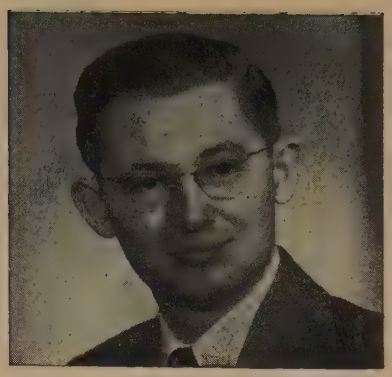
MATERIALS for MICROWAVES*



Dr. Benjamin Lax — Associate Editor
the microwave journal

Almost from the outset when microwaves assumed its gnificant role in radar during World War II, the prob- m of materials became an integral part of the micro- ave art. At that time, dielectric materials were re- uired for windows in microwave components, semi- nductors for microwave detectors, gases for T-R bes, liquids and solids as absorbers, and metallic con- uctors for containing and guiding the electromagnetic aves at these frequencies. To meet the requirements r practical systems during the wartime emergency, any of the solutions to the materials problems, by cessity, had to be approached on a practical basis. he research was Edisonian in character in which mate- ls were tried and tested on an empirical basis, and ose which worked satisfactorily were put to use and e others discarded. This shot-gun philosophy had to because of the circumstances. Costs were secondary, anpower and talent could be concentrated on the prob- m at hand, and high quality performance was often crificed when a workable solution was achieved. Re- arch on materials was sporadic, carried out only when had to be, and then hurriedly, with the investigations rected at the immediate objectives.

The philosophy of life toward materials has changed dically after the war. A science of materials has been olving gradually, although the explosive expansion of lid state and plasma physics recently might on the rface indicate otherwise. The initial activities which cused the attention of microwave scientists on mate- ls were in the area of microwave spectroscopy in ses, microwave gas discharge (which today is more shionably termed plasma physics), microwave prop- ties of dielectrics, and paramagnetic resonance. These ere soon followed by investigations of ferromagnetic sonance in metals and ferrites, and subsequently by spin resonance in metals, color centers, and in semiconductors. Following on the heels of the early resonance work on ferrites came the development of the nonreciprocal microwave components with its own special requirements for the unique properties of these ferrimagnetic materials. Semiconductors once again came under close scrutiny with the discovery of cyclotron resonance in germanium and silicon at microwave frequencies. These were shortly followed by more limited but encouraging results of cyclotron absorption in metals. Antiferromagnetic and ferrimagnetic resonance, following their theoretical prediction, were experimentally demonstrated at microwave frequencies when the suitable materials were properly selected and prepared. With the availability of single crystals of antiferromagnetic materials and the extension of microwave techniques to the millimeter region, antiferromagnetic and ferrimagnetic resonance was still further explored. The most dramatic by-products of microwave research on the properties of materials came when the maser and the parametric amplifiers were developed in a surprisingly short time after their conception. Paralleling all these discoveries and developments and supporting their continued growth is a science of materials which is slowly and surely emerging as a silent but indispensable partner of microwave science and technology. That the progress of materials is synonymous with progress in microwaves is perhaps best illustrated by examining the history of a few of these materials and their role in the development of the microwave art.

The first introduction of semiconductors to the microwave engineer came in the form of the crystal detector made of germanium and silicon. To be sure, the specimens were fabricated from polycrystalline material, which were prepared from the best chemically pure materials. No significant advances in this particular application were made until after the semiconductor art advanced radically with the advent of the transistor.

(*Continued on page 11*)

*The work reported in this paper was performed by Lincoln boratory, a center for research operated by Massachusetts stitute of Technology with the joint support of the U.S. my, Navy, and Air Force.

DOUBLE YOUR RANGE

WITH ONLY ONE CHANGE—ON X-BAND AND S-BAND MICROWAVE SYSTEM

You can now double the effective range of your X-band or S-band microwave system applications with no change in power requirements, no change in antennas, **no change in other system equipment!**

How? By using Hughes PAX-1 or PAS-2B backward-wave amplifiers in your microwave systems you will achieve noise characteristics much lower than from any other traveling-wave tube. **The lower the noise level, the longer the effective range!**

Recent advances in electron gun design (resulting from noise phenomena studies conducted by Hughes R & D laboratories) make possible the extremely low noise characteristics of the Hughes PAX-1 and PAS-2B tubes.

In your microwave system applications, these amplifiers alone offer you **advantages not obtainable by any combination of other low-noise devices.**

Only one voltage to vary... Another important feature of the PAX-1 and PAS-2B backward-wave amplifiers is a narrow, electronically tunable passband covering the entire X-band or S-band spectrum. This feature automatically provides image rejection, excellent selectivity and anti-jamming capability. And, once the initial setup has been made, **only the tuning voltage needs to be varied for complete operation.**

SPECIFICATIONS:	PAX-1 (X-Band)	PAS-2B (S-Band)
Minimum noise figure	4.5 db	under 4.0 db
Gain	over 20 db	10-25 db
Tuning voltage	420-650 v	180-1150 v
Maximum voltage	1500 v	2750 v
Bandwidth	12 mc	11 mc
Input-output isolation	over 50 db	over 50 db
Filament power	6 w	10 w
Magnetic field	1300 gauss	1000 gauss
Saturation power output	0.2 mw	1 mw

Write now for detailed specifications on the PAX-1 and PAS-2B: HUGHES PRODUCTS, Electron Tube Division, International Airport Station, Los Angeles 45, Calif. For export information, write: HUGHES INTERNATIONAL, Culver City, Calif.

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oday, both germanium and silicon can be tailored to rovide single crystal platelets with controlled impuri-es whose impedance and surface properties is optimized r the particular frequency utilized. These techniques e responsible for the improvements in the crystal de-ctors which are used in the millimeter region. Funda-ental research which is usually much more exacting on e purity and perfection of materials received a bonus om the ultra-pure crystals evolved from the zone re-ied semiconductors. Cyclotron resonance which re-uired germanium and silicon with impurities less than ie part in a billion, was successful in measuring the sic parameters of holes and electrons in these crystals r the first time. At the same time, spin resonance in licon, with its hyperfine structure, supplemented the clotron resonance results. This was achieved only cause the capability of preparing highly pure material as combined with the ability to introduce a controlled nount of donor impurities in accordance with pre-ribed specifications. Today, very pure crystals of rmanium and silicon act as host to magnetic impurities the transition elements enabling the measurement of eir fundamental properties as paramagnetic atoms d thus providing potential candidates of paramagnetic aterials for masers. The diffusion of impurities, a chnique which forms the backbone of the transistor dustry, gave rise to the development of diodes with st the right properties needed to exploit a device at icrowaves whose basic concept dates back to Rayleigh. rametric amplifiers would not be a reality without the odern technology in semiconducting materials. The velopment of parametric amplifiers for higher fre-iencies today is primarily a problem in materials, in e preparation of better crystalline diodes with the cessary characteristics whose specifications are known, t not yet matched. It is already recognized that a aterial such as gallium arsenide has a great potential a parametric diode. The stumbling block is the in-ility of the materials scientist to prepare crystals of ese materials with the necessary purity and perfection achieve the ultimate possibility offered by the intrinsic ectronic properties of gallium arsenide. Still another icrowave device on the horizon whose future is in-mately involved in the preparation of suitable speci-ens of germanium is the low temperature microwave vitch needed to isolate the maser in radar systems.

The early experiments on ferromagnetic resonance ere performed on metals. These have eventually led the beautiful experiments on spin waves in thin films cently. However, if we are to look for a classic exam-e of the strong interaction of materials and ferromag-tic resonance, ferrites and its related ferrimagnetic rnets are excellent illustrations. Ferrites as electronic aterials are the contributions of the Dutch scientists the Philips Laboratories who recognized its potential a microwave material rather early and developed a riety of these materials for this purpose. However, was the Bell Telephone Laboratories with its inte-ated team of physicists, engineers, chemists and metal-rgists, whose combined talents in microwaves and aterial development, who were responsible for the eakthrough which has led to the invention of many the microwave ferrite devices existing at the present time. Although the purity problem in ferrites has not been as severe as in semiconductors, the task of growing single crystals for basic measurements has been more exacting. This has been particularly difficult where the chemical composition of the ferrite had to be varied. For practical applications where polycrystalline materials were suitable, the variation in composition proved to be feasible and extremely successful for extending the use of ferrites to higher as well as lower frequencies in the microwave spectrum. The search for new ferrimagnetic materials which was stimulated by these activities led to the recent exciting development of garnet materials which has proved to be both practical and also fruitful for basic investigations. The microwave measurements in the garnets has pointed out the important role of impurities in these materials and their influence on its resonance properties. The problem of purifying ferrimagnetic materials, therefore now looms as a serious challenge to the talents and resources of the physical chemist.

Paramagnetic resonance which has recently assumed an exalted position in the scientific community until recently has been a do-it-yourself effort insofar as materials were concerned. It is not surprising that paramagnetic salts was one of the first solid state materials to be examined by physicists. The technique of growing single crystals of paramagnetic materials from solution, i.e., the nitrates, sulphates, fluosilicates, etc., with their water of hydration or the complex cyanides and halides, did not require difficult techniques or complicated equipment. To dilute the concentration of the paramagnetic ion by a diamagnetic substitute was relatively simple and permitted the measurement of fine structure as the resonance line width was decreased. Thus the materials problem was comparatively a simple one until the maser came into the picture. Then, even the initial experiments had unique requirements. The first maser required a complex material in which the gadolidium ethyl sulphate was doped with cerium to adjust the lifetime of the levels appropriately. The success of the solid state maser as an amplifier over a wide frequency range was only possible by the growth of large single crystals of potassium cobalti-cyanide with the desired concentration of paramagnetic chromium. The task called for the ingenuity and experience of a physical chemist, and the physicist was no longer self-sufficient. With the demand for more practical maser systems, the search for new crystals became more intense and resulted in the discovery of ruby as a suitable material with the proper electrical and mechanical properties. The manufacture of this crystal required the sophistication and unique resources of a commercial organization, the Linde Company, which has pioneered in the utilization of the Verneuil technique for growing artificial gems.

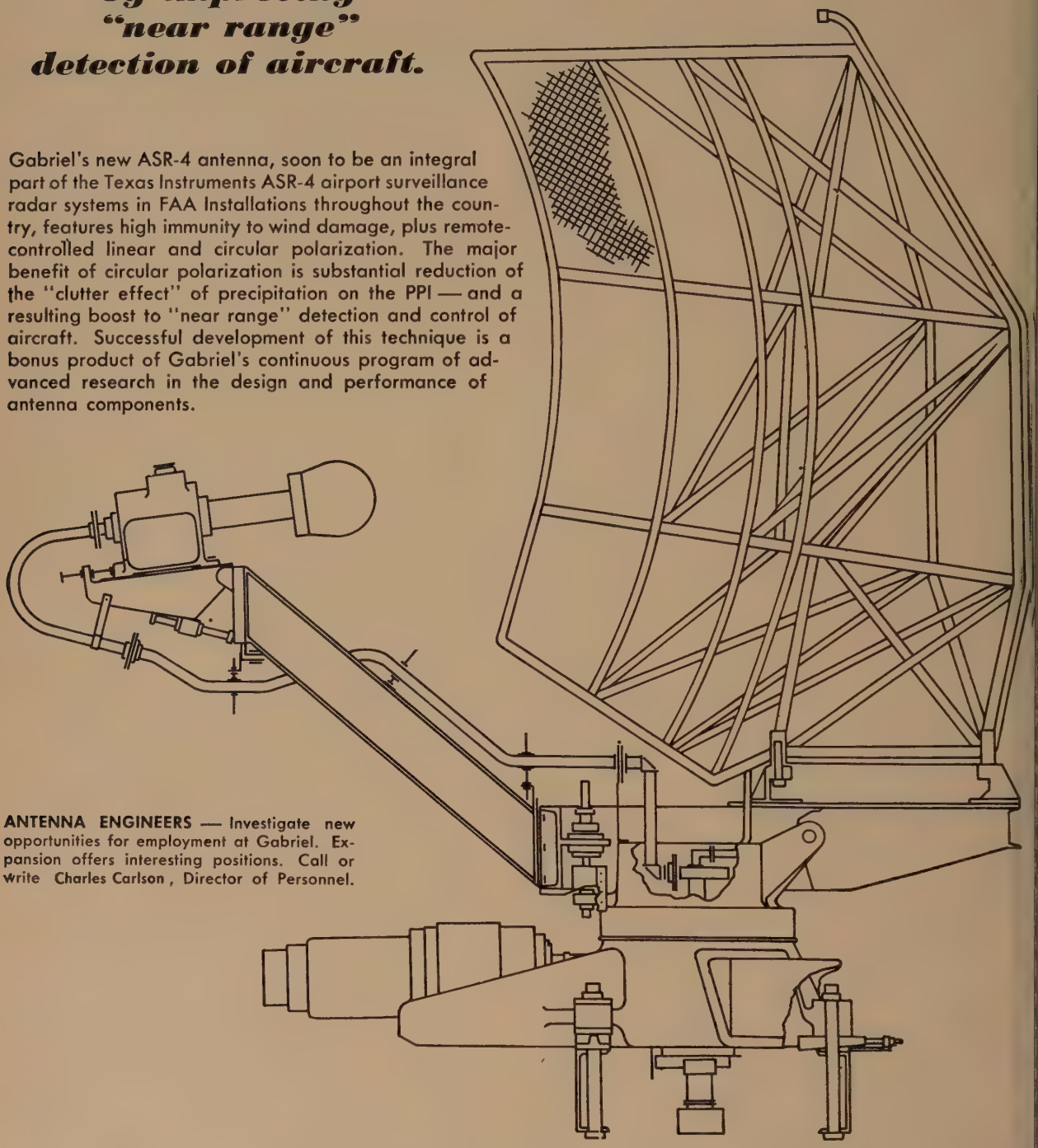
The story on other solid state materials, such as dielectrics, could also be related in length to show the bond between materials science and the microwave art. The newer ferrimagnetic and antiferromagnetic materials have a somewhat different history. The prepara-

(*Continued on page 13*)

GABRIEL'S NEW ASR-4 ANTENNA

. . . provides greater safety for airports by improving "near range" detection of aircraft.

Gabriel's new ASR-4 antenna, soon to be an integral part of the Texas Instruments ASR-4 airport surveillance radar systems in FAA Installations throughout the country, features high immunity to wind damage, plus remote-controlled linear and circular polarization. The major benefit of circular polarization is substantial reduction of the "clutter effect" of precipitation on the PPI — and a resulting boost to "near range" detection and control of aircraft. Successful development of this technique is a bonus product of Gabriel's continuous program of advanced research in the design and performance of antenna components.



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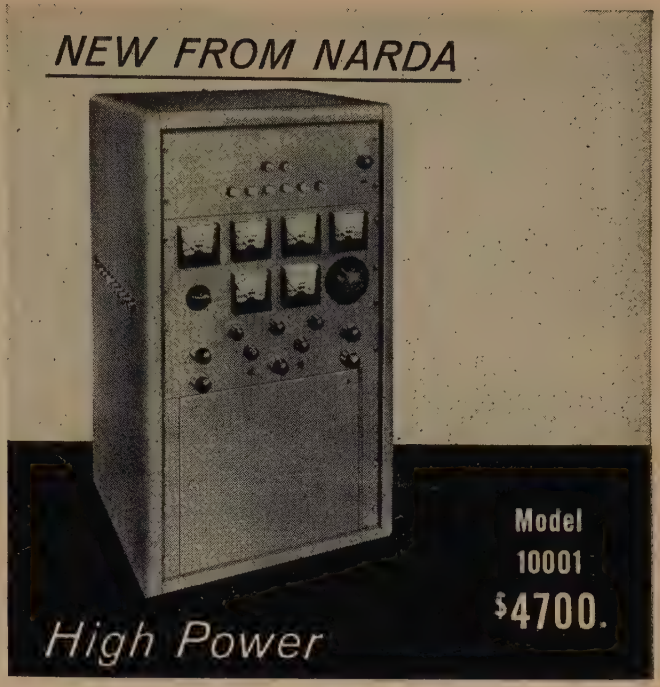
n of these materials requires special skills and facili-
s, and the few single crystals that are available often
ve come from a few isolated sources. The oxides and
ilar crystals which have very high melting tempera-
es often require difficult flame fusion or Verneuil
hnique for their preparation. The garnets which can
prepared from the melt require experience and skill
order that sufficiently large crystals be grown for
re extensive investigations. Good crystals of the
ali-halides which are used in spin resonance and other
eriments have also come from commercial sources
ich are tooled up to grow such crystals, primarily for
optical industry. The preparation of ultra-pure
stals of the alkali-halides which are badly needed
research is a difficult task whose achievement is still
ore us. The tale of other materials which are less
ensively used can be told in a similar vein. In short,
microwave scientist must often depend on others
his materials and may have to wait for major tech-
logical advances, spurred by practical developments,
ich will then provide him with the kind of materials
would like to have.

There is also a materials problem in gasses, either
microwave spectroscopy or plasma physics, which is
newhat different than those of the solid state, and at
same time, has some aspects which are quite ana-
ous. Obviously, for either of these areas it is neces-
y that the gas to be studied be relatively free of other
impurities. In general, this is reasonably well
ieved by the spectroscopically pure gasses obtained
mmercially. In the plasma work where it has been
essary recently to go to extremely low pressures, the
blem becomes more critical in another way. It is not
y necessary that the gas itself to be studied is pure,
it is also necessary that the container which might
it impurities during the discharge be also out-gassed
purified. For microwaves, usually the containers are
en made of very pure copper which are then out-
sed at high temperatures. The large systems needed
basic plasma diagnostics by microwaves are made
stainless steel. Very high vacuum techniques, which
lude low temperature condensing surfaces, permit in
ie cases a level of purity which is sufficient. How-
r, in plasma physics today the question of impurities
ich are introduced into the system is one of the
jor problems.

The above is a brief but pertinent account of the con-
utions that materials science has made to microwaves.
future of the microwave art appears to be wedded
n more to materials. The important question is how
the marriage between these two fields be made most
ctive. It is recognized now by the members of both
t the materials problem is an extensive one which re-
res the contribution of many scientific disciplines. The
step in the process involves the chemical components
the related question of purity. This may require an-
ical, spectroscopic, fluorescent and other related tech-
ues. In some cases, as in semiconductors, these are in-
quate at best and must be supplemented. One of the
st promising is mass-spectrometry which has been quite
cessful for volatile materials. For solids, this is not
ightforward and requires the development of a sophis-
ted and expensive machine which should be an im-

(*Continued on page 14*)



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accepts over 40 magnetrons!

Here's the first of a series of new products from Narda's recently-established High Power Electronics Division! A high power Microwave Modulator that permits installation **inside the unit** of any of more than 40 magnetrons! Complete, compact and self-contained, it accepts magnetrons covering 3,200 mc to 35,000 mc, with peak outputs from 6 KW to 120 KW. Model 10001 features a completely interlocked circuit, with all high voltage leads and connections **internal**, for maximum safety; solid state high voltage bridge rectifiers for longer life and reduced heat output (prolonging life of other components, too); and built-in meters and viewing connectors for all principal parameters.

Other features are shown below. For complete specs and a list of at least 40 magnetrons suitable for use with the 10001, write Narda's High Power Electronics Division (HPED) at Dept. MJ-7.

SPECIFICATIONS

High voltage supply: Continuously variable from 0 to 4 KV at 100 ma; **Magnetron filament supply:** Cont. variable from 0 to 13 volts at 3 A; **Rep. rate generator range:** Cont. variable from 180 to 3000 pps; **Pulse width:** 1 microsecond at 70% points, rise time 0.15 microseconds, max. slope 5% (other pulse widths available); **Size:** 38" h, 22" w, 18" d. **Weight:** 150 lbs.

Complete 1959 catalog available on request.

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provement over existing methods by perhaps two orders of magnitude. The next step in the process is the question of preparing the materials in either polycrystalline or single crystal form. In this area, depending on the material, we need chemists, ceramicists, metallurgists and even some physicists. To advance the art of preparing new and exotic materials, a variety of techniques must be explored, and among them the techniques of very high temperature and high pressure is extremely important and promising. Some of these avenues will undoubtedly require specialized facilities and costly installations. After the material is prepared, it is necessary to characterize its properties. Its mechanical strength, crystal structure and state of perfection has to be studied as well as the chemical content of the final result. The stoichiometry, order-disorder and surface properties often play a critical role in the ultimate utilization by the microwave people. For proper characterization, the optical, electrical and magnetic properties should also be studied at high and low temperatures with all the sophisticated and delicate instruments available to the physicists. Then the microwave physicist with his intricate and often very precise measurements must test the basic properties which enter into the variety of phenomena that he hopes to explore. The results are then the data which the microwave engineer requires to design and develop his devices. Both the engineer and the physicist then provide information feedback to the materials people, thus closing the loop which forms the basis of the partnership between these efforts.

A number of suggestions and proposals have been made during the last few years to augment and improve the materials effort nationally and to accelerate the proc whereby new materials are discovered, developed, inves gated and are more fully exploited. Some of these p posals recommended the creation of a large national l oratory which would hopefully attract many of the talen scientists of the various fields who would then work gether harmoniously toward a common goal. This labo tory would be equipped with all the modern tools a facilities needed for advanced research on materials. T laboratory would be a haven for creative people w would invent and produce a variety of new and interesti crystals that do not exist today. The laboratory would a be a source of materials for scientists in universities, g ernment and other laboratories. In addition, it would a clearing house of information on scientific matters garding materials as well as their availability. This is ambitious and well-intentioned plan. However, it is the one that is best suited to the circumstances that prev at the present time. That we need more extensive a better integrated and equipped effort in materials is in argument. Small isolated efforts in this field to located all over the country are not by large the answ either, although support for the rare brilliant individ should still be continued on this basis. The answer, believe, is somewhere between these two extremes.

Research relating to materials is most effectively d when the effort is above a critical size. Furthermore, addition to the materials preparation and those activit directly related to it, other scientific programs in physi measurements and in applications should be associated w such an effort, where possible. Of course, the large

(*Continued on page 20*)

WAVEGUIDE TUBING

formed and bent to close-tolerance specifications

KENT EXPERIENCE in forming waveguides to precise requirements dates back to the pioneering days of mic wave. **KENT QUALITY** is attested by the dozens of leading makers of high-performance equipment who entrust th most complex forming-bending problems to Kent engineers. **KENT FACILITIES** — largest in the country for v ume-production runs — are also geared to the development of prototypes. **KENT COSTS** are often lower because exceptional stock of waveguide bending and forming tools eliminates special tooling charges on many jobs. And **KE QUOTATIONS** are dependably prompt.

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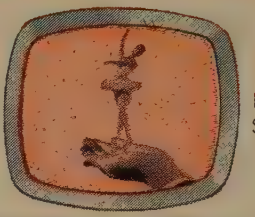
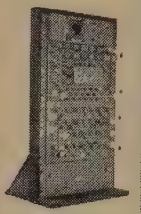
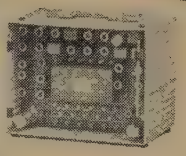
FOR WIPES & MATTING, MODEL 490A



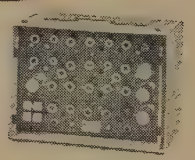
Insert Keying with Super Stability



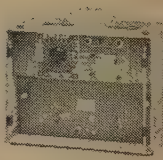
Rack Mounted



490W1 Waveform generator. Generates keying signals for the 72 different wipes.



490S1 Switching Amplifier. Combines two picture signals in accordance with applied keying waveform.



490R1 Remote Co trol Unit. Selects ar controls desired e fect. Designed f console or des mounting. Easi modified for integr tion into existing st dio facilities. Com plete with powe supply—512CR

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Single crystal synthetic sapphire rods are being used as support members for TWT helices and electron gun structures.

Sapphire offers flexural strength at elevated temperatures, excellent dielectric properties, small-diameter rigidity, strength at elevated temperatures, low-loss characteristics, zero porosity, and economy.

In addition to rods, single crystal sapphire is available in the form of windows and domes for microwave and infra-red systems. Special sapphire shapes for custom applications can be obtained.

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No other sweeping oscillators offer as many solid advantages as Alfred Electronics' new series 620 models, built by the industry's leading manufacturer of high quality, broadband microwave instruments. Note these features:

★ **Six models, covering 1 to 18 kmc.** Broadest frequency range available. Electronic sweep of RF output, or extremely stable CW operation.

★ **Linear frequency sweep coverage** over all or part of each band for rapid evaluation of reflection coefficient, gain, attenuation and other network transfer characteristics.

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★ **Quick Look readout.** See frequency range, markers and sweep time at a glance. No cumbersome calculating.

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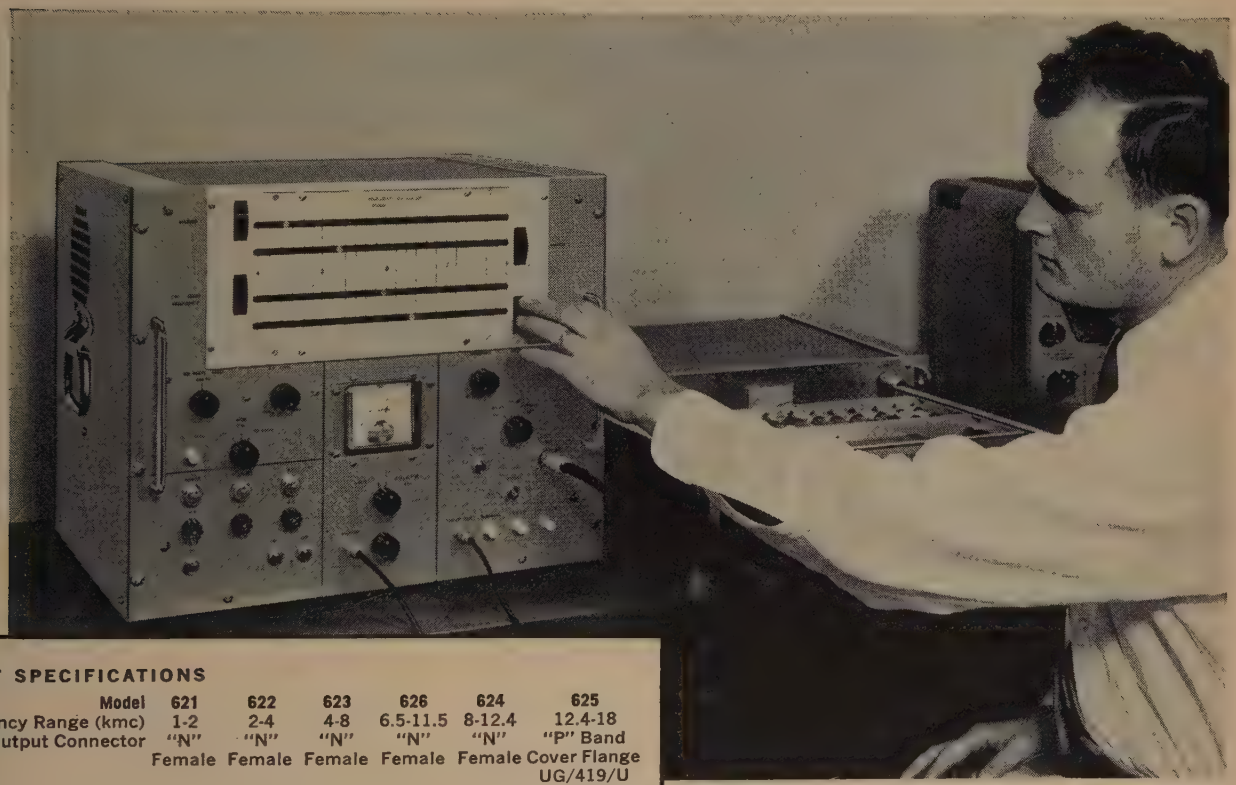

Using Alfred Model 623 Microwave Oscillator (left) to test small signal and saturation gain of Model 503 Traveling Wave Tube Amplifier. Microwave Leveler, Alfred Model 704, holds power output from oscillator constant within ±1 db.

BRIEF SPECIFICATIONS

Model	621	622	623	626	624	625
Frequency Range (kmc)	1-2	2-4	4-8	6.5-11.5	8-12.4	12.4-18
RF Output Connector	"N" Female	"N" Female	"N" Female	"N" Female	"N" Female	"P" Band Cover Flange UG/419/U
Prices	$3090	$2990	$2890	$2990	$2890	$3450

GENERAL

FREQUENCY CONTROL: Continuously adjustable with direct calibrated dial. Calibration accuracy, 1%.

POWER OUTPUT (minimum): 10 mw. Continuously adjustable from zero to maximum.

VSWR (maximum): 2:1.

SWEEP

SELECTOR: Recurrent sweep, single sweep, CW, and external on panel switch.

CONTROL: Single sweep, triggered by panel button, or external positive going signal 20 volts or greater.

SWEEP WIDTH: Continuously adjustable from 0 to any part of entire frequency range.

TIME: 100 to .01 seconds.

MONITOR OUTPUT: Positive linear sawtooth, 45 volts peak; Blanking out, 75 volts negative.

EXTERNAL SWEEP: 200 volts gives full sweep width.

AMPLITUDE MODULATION

INTERNAL SQUARE WAVE: RF output alternately 0 and unmodulated CW value. Frequency 800 to 1200 cps.

EXTERNAL: 30 volts maximum signal increases RF output from 0 to maximum.

POWER INPUT: 105 to 125 volts; 60 cps.

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CIRCLE READER SERVICE CARD 12

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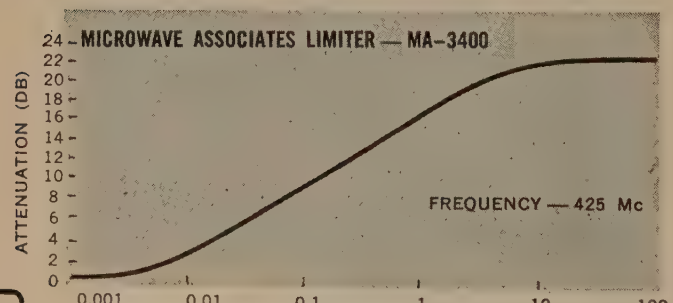
The specifications chart and performance curve below tell you all you need to know to evaluate its capabilities. The two models are typical of units which can be designed for your applications at other frequencies. The package has female Type N coaxial connectors, for input and output.

Today for UHF . . . tomorrow for higher frequencies.

SPECIFICATIONS

	MA-3400	MA-3401
Frequency (center)	425 ±5%	600 ±5%
Low Level Insertion Loss	0.3 db	0.5 db
Peak Power	400 watts	200 watts
Duty Cycle	.002	.002
High Level Insertion Loss	20 db	20 db



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CIRCLE READER SERVICE CARD 13

Letters

(*Continued from page 6*)

the microwave journal
160 Warren Street
Boston 19, Massachusetts

Dear Editor:

Reference is made to two excell articles in the February and June iss of *the microwave journal* by Mr. H. Finke with respect to "The Conservati of Engineering Talent." Of particu note is his reply to the question of "W can't individual companies work their own problems by raising the sa ries of top technical people?"

It is merely intended to supplem Mr. Finke's remarks in pointing out so of the practices among professional p ple in industry, accentuated by the sava competition for hiring and holding te nical talent, which tend to subterfuge preservation of high professional sta ards and technical prestige. One typi example is with respect to assignment professional ratings to those who ha not, for one reason or another, complet formalized their education and traini This does not imply that indiscrimin objection is being raised with assi ment of professional ratings to those w despite their lack of formal training, ha been carefully screened and observed o a reasonable length of time and ha demonstrated professional ability. Af all, education and training among ot things is generally an observation a screening process. However, what is jectionable, of course, is when profe ional ratings are granted without portunity to observe, screen, or dem strate.

In particular, reference is made to practice which smacks with proselyti whereby professional ratings are c ferred to "hire-ins" who formerly h semi-professional or technician ratings previous employment.

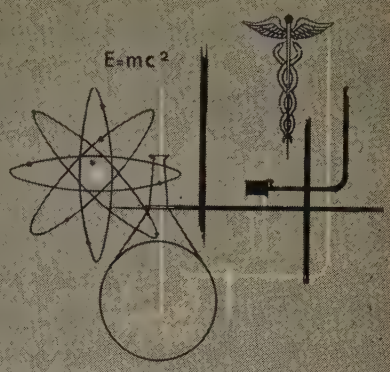
In a similar view, is the practice establishing semi-professional rati whose salary brackets parallel that of professionals, evidently the difference purely in the title. Then there are ot similar examples, but it isn't necess to labor the point.

Mr. Finke has indicated how the gineering profession can preserve standards and technical prestige and gi as an example what other professors doing about the matter. There isn't question that the engineering profess community as well as individuals sho become more cognizant of their sta ards; for, if one analyzes carefully situation, it is the members of the p fession who actually set the level of o ating standards by what they pract how they maintain it irrespective of severity of the competition or difficu of the problems.

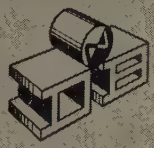
Sincerely yours,

E. A. Blasi, Chairman
Professional Group on Anten & Propagation
San Francisco Chapter

140 KMC



ULTRAMICROWAVE* EQUIPMENT BY



–it works–it's accurate–it's available

These millimeter wave units can greatly enlarge your scope of microwave activity. Research previously considered impractical at 140 KMC can now be carried on successfully.

De Mornay-Bonardi manufactures cavity wavemeters, crystal multipipliers, crystal mounts, E-H tuners, and standing wave detectors specifically for use at 140 KMC. They work—we've been using these units effectively in our own laboratories for developing other items. These instruments are accurate—functionally as accurate as De Mornay-Bonardi equipment used at 90 KMC. You can order these units now—we're currently filling orders on 140 KMC instruments.

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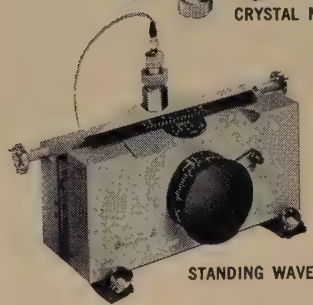
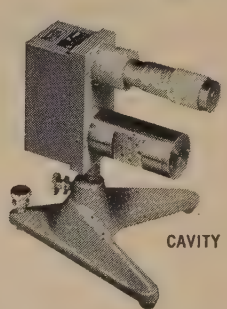


STANDING WAVE DETECTORS

CRYSTAL MOUNTS

E-H TUNERS



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*TRADE MARK DE MORNAY-BONARDI

AEL® INC.

THE LEADER IN...

CRYSTAL VIDEO DETECTION

CRYSTAL VIDEO DETECTOR MOUNTS

that can more than triple the range of existing microwave beacons and provide countermeasure systems with tangential sensitivities as high as —65 dbm. Available with standard brass connectors and bodies . . . or aluminum for LIGHTWEIGHT applications. (available with type N, TNC, Miniature, and BNC connectors).

Mounts available from 50 Mc/s to 12 KMC in continuous or octave bands in coaxial configuration. Higher frequencies in waveguide.

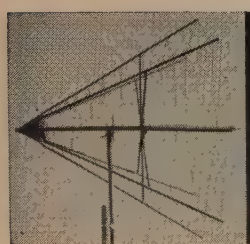
REDUCE SYSTEM POWER DRAIN • CUT WEIGHT
CUT COST • EXTEND DETECTION RANGE

TRANSISTORIZED VIDEO AMPLIFIERS
for Crystal Video Detection

Transistorized or hard-tube crystal video receiver amplifiers designed with high input impedance to prevent crystal detector loading. Other features include . . . low equivalent noise, high gain, crystal bias circuits, small size and LIGHT WEIGHT. Several "standard" models available or units built to your specifications.

AND

BROADBAND ANTENNAS



AEL's Broadband circularly polarized conical helix antenna, matched over greater than 10 to 1 frequency bands, is ideally suited for countermeasures and telemetering applications. The teardrop pattern, of essentially constant beamwidth, provides a unique broadband, circularly polarized feed antenna for parabolic reflectors.

Frequencies from 40 Mc/s to 8000 Mc/s

AEL has built VHF-TV Slotted Cylinders, Air Inflated Monopoles, Discones, Horns, Airborne Blade and many other antennas. For solutions to your antenna problems contact AEL for the services of a highly skilled team of antenna design engineers working in our modern high frequency and microwave laboratories at AEL's 50 acre tract in Colmar Penna.

Investigate the opportunities at AEL for creative engineers

AEL AMERICAN ELECTRONIC LABORATORIES, INCORPORATED
121 N. 7th ST., PHILADELPHIA 6, PENNA.

In Canada contact: Conway Electronic Enterprises Regd., Toronto, Canada

CIRCLE READER SERVICE CARD 15

(*Continued from page 14*)

tional laboratory would achieve these objectives. Howev if created, it would attract existing talent who lead su cessful programs elsewhere which would suffer if this w to occur. Today there exists a number of laboratories universities, in government and also in industry wh have the elements of diversity and good people arou whom a materials effort could readily be built. Until cently, the people who have been concerned with grow and preparing crystals have either been in a supporti and service role, or as in a university, have engaged independent operations which have had little interact with the physicists or engineers. Large industrial labo tories have come to recognize the importance of mater and have created teams whose size and activities are ginning to match those which it supports and complemen This of course is not possible for small industry or ma of the smaller colleges or universities. However, strengthening the existing efforts in the larger univers in appropriately selected regions of the country wh the conditions as to size, quality and kind of people gaged in these activities is fulfilled, also in some gove ment laboratories where a similar situation prevails, t the materials effort of the nation could be appropria expanded and at the same time serve the scientific co munity more effectively. The sponsors of this additio support should encourage these larger organizations supply materials and information, where possible, to small university and industrial groups who would gre benefit thereby. Actually, this type of cooperation alre exists in large laboratories like Bell Telephone Laborat General Electric. Some of the service laboratories larger sponsored laboratories have indeed been supply materials to individual scientists. This scheme would p vide greater diversity and complementary activities, in some cases may result in some overlap and perh necessary duplication. The latter is often desirable moderation since competition and independent ideas similar and related fields often are the best way to ins maximum progress. The microwave research in many these laboratories should be an integral part of the ove activities which would then strongly interact and ben from the research and development in materials. proper advancement of materials for microwaves and o fields of science which will insure further significant velopments will for the most part be made by groups wh are above sub-critical size where the variety of discipli consisting of chemists, ceramicists, metallurgists, physic and engineers are intermingled and work together as te on a variety of problems in which each is familiar t lesser or greater degree with the objectives of the ot But above all, the support on this intermediate tho larger scale should only be given where there are first- or creative scientists with imagination and resourceful and where the climate and atmosphere is conducive t productive effort. Scientific research of this type sh be built around people who have demonstrated scien leadership and who have established a reputation for ativity. The creation of laboratories which is motiva primarily by political considerations in an environm which does not meet the proper requirements is waste Support should be provided and expanded only where search flourishes, and conversely where it does not should be discontinued and withdrawn.

THE HUMAN FACTOR in today's technology

Scientists have long been preoccupied with the technological problems of Man and the Machine. The increasingly complex nature of advanced systems has created an urgent need to enhance man's contribution to effective systems performance. The complicated nature of this relationship requires the skills of psychologists, social scientists, mathematicians, and engineers.

At Ramo-Wooldridge, human engineering, personnel selection, individual and system training, display design, and communications are successfully integrated into systems design and development by the technique of large-scale simulation.

Simulated inputs enable scientists to observe a system as it operates in a controlled environment and make possible the collection of data on performance, training, human engineering, maintenance, and logistics and support. Scientists and engineers use this data to assure the design, production, and delivery of a unified system capable of high performance and reliability.

Expanding programs at Ramo-Wooldridge in the broad areas of electronic systems technology, computers, and data processing have created outstanding opportunities for scientists and engineers. *For further information concerning these opportunities write to* **Mr. D. L. Pyke.**

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a division of ***Thompson Ramo Wooldridge Inc.***

26 NEW TYPES ADDED TO BENDIX NOISE SOURCE TUBE LINE!

Freq. Range KMC	Band	Waveguide Number	Bendix Type Number	RETMA Type No.	Mount Type	Recommended Mode of Operation (Note 2)	Anode Current Ma (Note 1)	Tube Drop Volts (Note 1)	Tube Excess Noise Ratio DB (Note 3)
1.12-1.70	L	RG-69/U	RXB103085		10°E	D.C.	250	130	15.2
			TD-21	6881	90°H	D.C.	250	65	15.2
			TD-29	7101	90°H	A.C. and D.C.	250	130	18.0
			TD-33		90°H	A.C. and D.C.	250	75	15.2
2.6-3.95	S	RG-48/U	TD-12	6358	10°E	D.C.	250	80	15.2
			TD-22	6782	90°H	A.C. and D.C.	250	45	15.2
			TD-31		10°E	A.C. and D.C.	250	85	15.2
			TD-32		10°E	A.C. and D.C.	250	140	18.0
			TD-34		10°E	D.C.	250	155	18.0
			TD-35		90°H	A.C. and D.C.	250	80	18.0
			TD-38		10°E	PULSE*	(250)	(90)	15.2
3.30-4.90	S	WR-229	TD-24	6852	10°E	A.C. and D.C.	250	65	15.2
			TD-30		10°E	A.C. and D.C.	250	110	18.0
3.95-5.85	C	RG-49/U	TD-10	6356	10°E	D.C.	250	70	15.2
			TD-39		10°E	PULSE*	(250)	(80)	15.2
			RXB103422		10°E	D.C.	250	(110)	18.0
5.85-8.20	X	RG-50/U	TD-10	6356	10°E	D.C.	250	70	15.2
			TD-39		10°E	PULSE*	(250)	(80)	15.2
			RXB103422		10°E	D.C.	250	(110)	18.0
8.20-12.40	X	RG-52/U	TD-11	6357	10°E	D.C.	200	75	15.2
			TD-23	6882	10°E	D.C.	200	115	18.0
			TD-40		10°E	PULSE*	(200)	(85)	15.2
			RXB103093		90°H	D.C.	200	(35)	15.2
			RXB103394		90°H	A.C. and D.C.	(100)	(50)	15.2
12.4-18.00	K	RG-91/U	TD-18	6684	10°E	D.C.	200	70	15.2
			RXB103399		10°E	D.C.	200	(110)	18.0
			RXB103409		10°E	A.C. and D.C.	(100)	(65)	15.2
			TD-41		10°E	PULSE*	200	(80)	15.2
			RXB103411		90°H	A.C. and D.C.	(100)	(50)	15.2
			RXB103254		90°H	D.C.	200	(40)	15.2
18.0-26.5	K	RG-53/U	TD-13	6359	10°E	D.C.	200	65	15.2
			RXB103423		10°E	D.C.	200	(100)	18.0
			TD-42		10°E	PULSE*	(200)	(75)	15.2
			RXB103411		90°H	A.C. and D.C.	(100)	(50)	15.2
26.5-40.0	K	RG-96/U	RXB103251		10°E	D.C.	(150)	(120)	15.2

NOTE 1: Anode current and tube drop are D.C. values. Values in parentheses are tentative.

NOTE 2: D.C. operation—Cathode at one end only.
A.C. and D.C. operation—Cathodes at both ends.
Pulse operation—Cathode at one end specially designed for pulse operation.

NOTE 3: The Excess Noise Ratio in DB is 10 log $\left(\frac{T\,eff}{290} - 1\right)$

*If the anode current during the "on time" of a square pulse (of greater than 100 micro sec. duration) is nominally the same as the rated D.C. anode current, the tube drop during this period will be approximately the same as the rated D.C. tube drop.

Expanding its line from 9 types to 35 types, Bendix Red Bank now offers a great variety of noise source tubes.

But great variety is only one advantage. Noise source tubes that are free from ambient temperature corrections are the result of making tubes so that no correction in noise figures is necessary from −55°C. to +85°C. What's more, long life and unusual stability result from precise quality control—far beyond the usually accepted tolerances for such products.

Whatever your applications, whether for 10° or 90° angle mounting, check with our specialists for the most efficient solution. Write RED BANK DIVISION, BENDIX AVIATION CORPORATION, EATONTOWN, NEW JERSEY.

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Red Bank Division

Bendix AVIATION CORPORATION

CIRCLE READER SERVICE CARD 17

INDUSTRY NOTES

CALL FOR PAPERS

The seventh annual Solid-State cuits Conference, sponsored jointly the Institute of Radio Engineers, American Institute of Electrical En eers, and the University of Pennsylva will be held on February 10, 11 and 1960, in Philadelphia, Pennsylvania.

Plans for the conference call for presentation of papers dealing with cuit properties, circuit philosophy, design techniques related to solid-s devices in the following general are

Thermoelectric, magnetic, and o solid-state circuit techniques for complishing conversion or control energy.

Microcircuit techniques for improv speed, increasing reliability, reduc volume, weight, and cost.

Solid-state digital-data storage te niques utilizing optoelectronics, c genics, twistors, etc.

Solid-state logic techniques as, for ample, multi-aperture magnetics, film circuit techniques.

Utilization of novel solid-state devi

Microwave-circuit techniques us solid-state devices such as parame amplifiers, masers, parametrons, etc

Linear techniques in solid-state cuitry which significantly advances art in flexibility, bandwidth, gain, bility, reliability.

Papers representing original contr tions in these and related fields — v emphasis placed on circuit proper and applications — are solicited. stracts (200 or more words) explain the nature of the contribution, its nificance, theoretical and experimental sults, should be mailed no later t October 9, 1959 to:

Tudor R. Finch,
Chairman, Program Committee
1960 Solid-State Circuits Confere
Bell Telephone Laboratories, In
Murray Hill, New Jersey

• ● •

DR. R. M. WILMOTTE JOINS RC ADVANCED MILITARY SYSTE STAFF

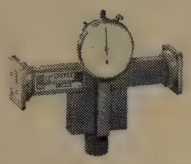
Dr. Raymond M. Wilmotte, rese consultant and authority in the field antenna theory, radar and commun tions, has joined the staff of Advan Military Systems, Defense Electr Products, Radio Corporation of Ame Arthur L. Malcarney, Executive V President, RCA Defense Electronic ducts, announced recently.

Advanced Military Systems is a h level scientific and technical organiza established by RCA at Princeton, N Jersey, to create and develop new advanced weapon system concepts.

Dr. Wilmotte has had broad exp ence as a research consultant in the of communication in both England the United States. Prior to joining

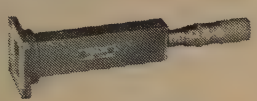
(*Continued on page 44*)

MICROWAVE TEST EQUIPMENT
WAVEGUIDE ASSEMBLIES



PRECISION CALIBRATED ATTENUATORS
8 units cover 2.60 to 40.0 Kmc/Sec
.5 to 40.0 db range at ± 0.2 db accuracy
Rugged design - broadband operation - low VSWR

CALIBRATED - SHIELDED ATTENUATORS
611 — 8.2 to 12.4 Kmc/Sec
711 — 12.4 to 18.0 Kmc/Sec
.3 to 35 db
1.15 Max VSWR



WAVEGUIDE ADJUSTABLE SHORTS
Non-contacting shorts — micrometer or knob adjustments — non backlash.
Type 661 8.2 to 12.4 Kmc/Sec

MICROWAVE NOISE SOURCES
Waveguide tube mounts and power sources provide direct reading noise measurements 2.6 to 40.0 Kmc/Sec.
2200-8-DR
18.0 to 26.5 Kmc/Sec

Precision Test Instruments
2600 to 90,000 MCS.

A complete line of test instruments . . . precision built . . . rugged in design . . . easy to operate and maintain . . . for laboratory or field use . . . versatile. Dependability and low cost are achieved by the latest volume production techniques. A 90 page catalog available upon request describes over 600 instruments and presents photos, electrical and mechanical data, charts, curves and engineering information.

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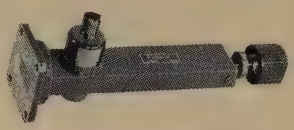
PHASE SHIFTERS
DETECTOR MOUNTS
PRECISION TUNERS

SHIELDED LEVEL-SET VARIABLE ATTENUATOR
8.2 to 12.4 Kmc/Sec
.2 to 20.0 db Locking



DETECTOR MOUNTS
Broadband Crystal — Bolometer mounts fixed and tunable — non contacting shorts — R.F. chokes — twenty types cover all bands —
Type 614
8.2 to 12.4 Kmc/Sec

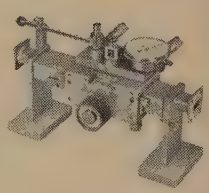
STANDARD GAIN HORNS

8 units cover 2.60 to 40.0 Kmc/Sec — 15 db gain — 30° beam width — low VSWR rugged design — gold plated — calibrated

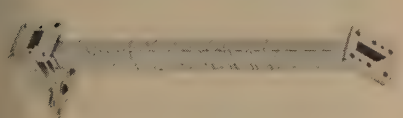
SLOTTED SECTIONS

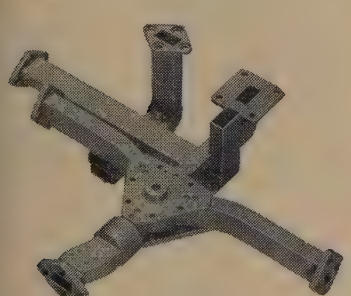
Designed to provide maximum accuracy and sensitivity. Nine units cover 2.60 to 40.0 Kmc/Sec.

Type 764



Cavity Machined to Tolerance of .0005 ins.
Cavity Brazed to Tolerance of ± .001





TYPICAL RIGID PRODUCTION SPECIFICATIONS

Angular ± 0° 15′
Squareness and Parallelism .002 in. per in.
Machined Dimensions ± .002 in.
Brazed Dimensions ± .005 in.
Surface Finish 32
Pressure 15 PSI
Material 6061-T6 Alum. Alloy

CUSTOM MICROWAVE ASSEMBLIES
Brass . . . Aluminum Magnesium

Complete facilities for the design, development and production of assemblies to the customer's special requirements. Utilization of the most modern manufacturing techniques makes possible the low cost, high volume production of all Microwave assemblies including extremely complex units such as those pictured here.

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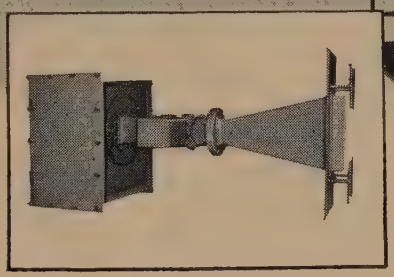


Added performance for added safety. New I-T-E antenna system will extend the range of airport surveillance radars to 50 miles radius, 30,000 ft. coverage.

I-T-E circular polarization feed system penetrates rain, clouds and dust to give more positive location of traffic in poor weather.

Advanced I-T-E Antenna Systems Play Importa Roles In FAA Airways Modernization Progra

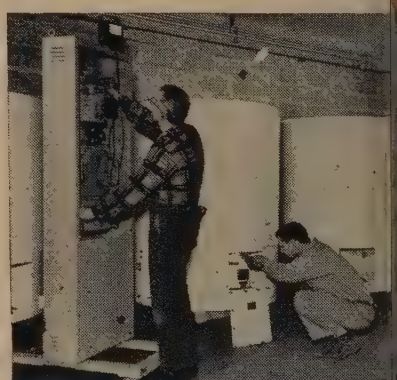
Surveillance radars at major airports throughout the country will soon be equipped with completely new antenna systems for added safety in the control of jet age air traffic. This project will mark the second phase in the FAA's program to improve their performance and extend their range. I-T-E has participated in both phases.

Initially, I-T-E developed and supplied kits for adapting circularly polarized feed to existing ASR-2 and -3 antennas. This modification provided clearer, more easily observable scope displays, uncluttered by echos from clouds, rain or dust. And now, under a new FAA contract, I-T-E has embarked upon the design and production of 50 replacement antenna systems which will extend the range of ASR-1, -2, and -3 surveillance radars to 50 miles, coverage to 30,000 feet. The new systems will also provide the advantages of circular polarization.

I-T-E is also engaged in another phase of airways modernization—the production of TACAN (TACtical Air Navigation) antenna systems for both land and shipboard use. Advanced types are now under development. Other I-T-E antenna projects range from compact systems for ultraprecision tracking radars to multi-megawatt giants for distant early warning.

If you are faced with a problem concerning antenna systems—for radar or scatter communications—benefit from I-T-E's extensive design experience and production facilities. Address your inquiry to I-T-E Special Products Division, and ask for your copy of I-T-E's valuable Antenna Handbook (2nd Edition).

Engineers: Challenging opportunities are available at I-T-E in radar and scatter communication antenna system design.



For more accurate air navigation. I technicians perform final tests on TA antenna systems and control consol operation, precision modulated an signal provides suitably equipped ai with direct indications of range and be

I-T-E CIRCUIT BREAKER COMPANY
Special Products Division • 601 E. Erie Avenue • Philadelphia 34, Pa.

ARRY K. BERLAND was born in Decatur, Illinois in 1925. During World Var II he attended the USAAF Pre-meteorology program at the University of hicago and received radar training at No. 5 Radio School, RCAF, Clinton, ntario. He then served with the 10th Weather Squadron in India in a radar pacity.

In 1949 he graduated from Washington University in St. Louis with a B.S. E.E. and joined the Radar Department of Emerson Electric. Mr. Berland has een actively engaged in the development of airborne fire control systems for t bombers, ground based and shipborne projectile tracking radars, and missile zing devices.

He is presently the Head Propagation Engineer in charge of microwave sys-ms design. Much of his current interest lies in the fields of coherent signal pro-ssing and advanced systems analysis.

BERNARD J. LAMBERTY received a BSEE degree from Illinois Institute of Technology in 1950. After a year as a graduate student and a research associate at the Antenna Laboratory of Ohio State University, he became affiliated with Gilfillan Brothers as a design engineer in the microwave section.

In March of 1955 Mr. Lamberty accepted a position on the faculty of the Electronic Engineering Department at California State Polytechnic College. He was inducted into the army in June of 1955 and was assigned to the Telemetry Research Branch of the Range Instrumentation Division at White Sands Proving Ground. While serving in the Army he was a part-time instructor with the Electrical Engineering Department at the New Mexico State University.

After his release from the Army in March 1957, Mr. Lamberty returned to his position at California State Polytechnic College. In September of 1957 he joined the Antenna Section of the Sylvania Electronic Defense Laboratory where he is presently engaged in broadband antenna systems research and development.

Mr. Lamberty is a member of the IRE.

OY A. PAANANEN is a Section Head in the Crossed-Field Tube Laboratory of ie Raytheon Microwave and Power Tube Division. Since joining the company in 953, he has contributed to research and development of high power backward ave oscillators for many microwave frequency bands.

Mr. Paananen attended Michigan State University and received his bachelor f Science Degree in Electrical Engineering in 1949, graduating with high honors. ecipient of a research assistantship at MIT, Mr. Paananen then spent a short eriod taking advanced studies at Harvard before entering the Institute. For the ext four years, he studied advanced electrical engineering and conducted research udies at MIT's Research Laboratory, receiving his E.E. degree in 1953. His thesis, Receiver Design to Reject Interference," based on his laboratory research work, as published by TV AND RADIO ENGINEERING in 1953. Prior to receipt of is E.E. Degree, Mr. Paananen also worked at the Institute's Lincoln Laboratory Bedford, Mass., on government classified research and development.

Mr. Paananen is a member of the IRE (Associate), Phi Kappa Phi, Tau Beta , Pi Mu Epsilon, and Sigma Xi.

FREDERICK W. VORTMEIER was born in St. Louis, Missouri on September 15, 1928. He attended Washington University in St. Louis, receiving a B.S. degree in electrical engineering in 1951.

Upon graduation he worked at McDonnell Aircraft Corp. in the helicopter division as an instrumentation engineer. He then spent two years in the armed services with the Signal Corps. During this period he was assigned to the Signal Corps Engineering Laboratories at Fort Monmouth as an electronic research assistant.

Since 1954 Mr. Vortmeier has been employed by Emerson Electric of St. Louis. He is presently a senior engineer in the Propagation Section, and is in charge of the design of the microwave system for a land based tracking radar.

NEW FROM NARDA

Wide Range

KLYSTRON POWER SUPPLY—$475.00

Operates more Klystrons than any comparable unit!

This new Narda Wide Range Klystron Power Supply operates virtually all medium and low voltage Klystrons, as well as some high voltage tubes (at reduced power output). It literally operates more Klystrons, including Sperry and Varian tubes, than any other unit in its price range!

What's more, all components, including tube sockets, are operated within manufacturers' ratings. (Many other supplies exceed plate-cathode, cathode-filament or socket-ground voltage ratings.)

Want more information about this new Power Supply that gives you greater versatility and longer trouble-free service at lower cost? Then write us for complete spec sheets. Ask, too, for your free copy of our complete catalog. Address: Dept. MJ-6.

FEATURES

- **250-700 volt Beam Supply, 0-65 ma.**
- **0-1000 volt Reflector Supply**
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- **Square Wave Modulation 0-150 Volts, 300 to 3000 cps.**
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- **Sine Wave Modulation 0-150 Volts, 60 cps.**

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HIGH POWER X-BAND BACKWARD-WAVE OSCILLATOR

ROY PAANANEN
RAYTHEON COMPANY
Microwave and Power Tube Division

troduction

For the past several years design and velopment of M-type backward- ave oscillators have progressed stead- at Raytheon under the sponsorship the U.S. Signal Corps and the U.S. r Force. One result of this work is e QK634 X-band tube which has ently been declassified. This oscil- or, whose design is based on exten- e experience gained at S-band fre- encies, is voltage-tunable from 8150 11,000 Mc, and generates a mini- um of 156 watts with a nominal effi- ncy of 20%. The output of the K634 M-type backward-wave oscil- or may be modulated in either am- tude or frequency, and the tube may o be pulsed. Figure 1 is a photo- aph of the QK634 tube packaged th its toroidally-shaped permanent agnet.

scussion

In the following short discussion, e typical M-type backward-wave oscillator is compared with the O-type tube, which has been more completely described in unclassified publications. Both types of oscillators use space-extensive interaction between an electron beam and an rf wave on a slow wave structure to generate rf power. Both involve oscillation produced by distributed feedback of energy, and have similar distributions of small-signal voltage in their circuits. However, the M-type unit uses crossed magnetic and electric fields for interaction and consequently requires a magnet for this purpose.

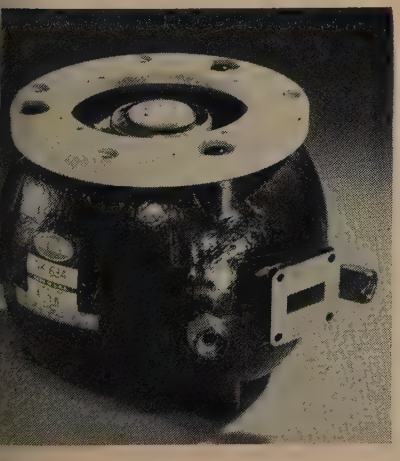


Figure 1

During operation of the O-type tube, kinetic energy is transferred from the electron beam to the slow wave structure or delay line. In the M-type tube, however, potential energy is transferred. Also, unlike the O-type tube, the M-type backward-wave oscillator requires a steady-state electric field in its interaction space and consequently needs two electrodes to establish this field. One of these electrodes is the delay line itself and the other is termed a "sole." The relative positions of the sole and the delay line are shown in Figure 2. Interaction between the electron beam and the rf wave takes place in the space between these electrodes.

Typically, the sole is operated at a negative bias whose magnitude is about 25% of the positive voltage applied to the delay line. In spite of its negative bias, however, the sole may intercept a variable fraction of the beam current because of a linear accelerator type of phenomenon which acts on unfavorably phased electrons in the beam.

Because of its mode of operation,

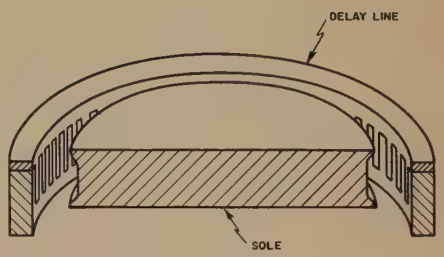


Figure 2 — Relative positions of QK634 delay line and sole.

the efficiency of an M-type backward-wave oscillator can theoretically be as high as about 75%, and at X-band frequencies, efficiencies between 20 and 35% can be realized. On the other hand, O-type backward-wave oscillators operate at efficiencies of only a few percent. Thus, O-type tubes are best suited for low power applications, and M-type tube units are suggested for generation of high power levels where operating efficiency is important.

Interception of a large fraction of beam current by the delay line is associated with the greater efficiency of the M-type tube. Such interception raises problems concerning the thermal dissipation characteristics of the delay line. In the O-type tube, where efficiency is rather low in any case, this interception of beam current is to be avoided if it is at all possible. In practice, this cannot be done completely and such tubes are, therefore, also practically limited by the dissipation of the anode.

Simple theory shows that the beam velocity in M-type tubes is proportional to the electric field across the interaction space while in O-type tubes this velocity is proportional to the

square root of the anode or delay line voltage. Consequently, the voltage-tuning characteristics of the two tube types can be expected to differ somewhat.

The fixed bias on the sole of the M-type has an important effect on the ratio of the maximum to minimum delay line voltages needed to voltage-tune a backward-wave tube through a given frequency interval. For example, in an O-type tube with a slow wave structure like that used in the QK634, this ratio of maximum to minimum voltage is 7.2 for a frequency range of one octave. In an M-type tube with such a delay line, this ratio is about 6.9 for a sole bias of —1600 volts but decreases to 3.2 at zero sole bias.

Although use of the sole electrode imposes some stringent mechanical alignment requirements in the M-type tube, this electrode can be used to provide very rapid frequency deviations over any small fraction of the total tuning band. If the carrier remains fixed at any frequency by maintaining the proper delay line voltage, the sole bias may be varied at rates as high as several megacycles to frequency-modulate the power output.

It is interesting to note that all O-type backward-wave oscillators are linear structures while most M-type tubes of this kind are circular in form, somewhat like a non-reentrant magnetron.

Delay Line Design

An important component of an M-type backward-wave oscillator is its slow wave structure or delay line. The type of delay line chosen as well as its dimensions affect to a marked degree the success of the tube design.

Experience has shown that the interdigital form of delay line is particularly suited for use in the M-type backward-wave oscillator. This structure supports a strong backward wave with only minor lateral variations and has a bandwidth adequate for the necessary tuning ranges. It has good thermal dissipation characteristics, and its dispersion characteristics are controllable and well understood. In addition, it can be matched to an output system without difficulty, and can be mass-produced with the required precision. At Raytheon, hobbing techniques [1] have been used extensively to manufacture the interdigital delay line components for M-type backward-wave oscillators. Figure 3 shows the form of the interdigital line and the various dimensions which must be considered in designing it. Figure 4 is a photograph of the QK634 delay line mounted in the anode shell.

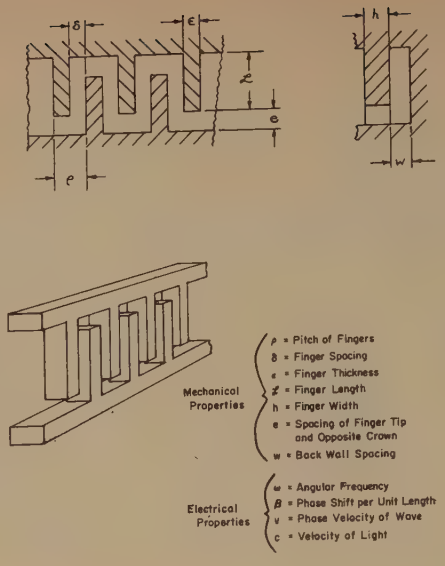
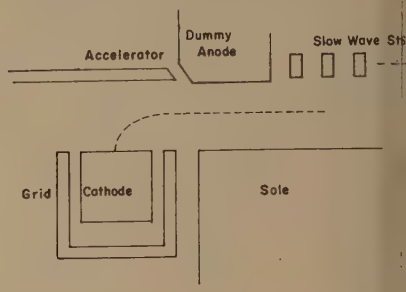


Figure 3 — Interdigital delay line nomenclature.

Figure 5 — Transverse section of "sl optics" gun.



The techniques for predicting the c/v vs λ diagrams of interdigital lines, at least those of conventional forms, have been well described.[2] In the X-band tubes developed for the program discussed here, the delay ratio c/v ranged from approximately 13.5 at 11,000 Mc to about 24 near 8,000 Mc. These choices of values for c/v fix the pitch of the line and its finger length.

Other transverse dimensions shown in Figure 3 were chosen to obtain a suitable cutoff frequency and an adequately wide pass band while providing the most favorable compromise between coupling impedance and thermal dissipation as well as mechanical rigidity. With these dimensions specified, design of the remainder of the slow wave structure involved selection of the proper number of fingers for the active length of the line as well as the number of fingers of attenuative length used as an inte termination, choice of the attenua material for covering the fingers the attenuative section, and provis for an rf output terminal or transi unit. Calculation of the active len was based on scaling and space-cha free interaction theory, while known behavior of the chosen at uative coating more or less fixed length of the attenuative section.

The transition unit consists o coaxial line with one end connec to the terminal finger of the delay and with the other connected t Mumford-type [3] junction that fe the external RG52/U waveguide. antenna of the junction is surroun by a low-loss ceramic cap that prov a vacuum seal and permits tube eration at the desired power level

Figure 4

Electron Gun Design

The position of the QK634 elect gun relative to the slow wave st ture and the sole is shown in Figur In this arrangement electrons at peak of the cycloidal arch into wh they are launched are subjected t step function in electric field that moves most of the undesired com nents of electron motion. This arran ment is based on a highly ideali situation — abrupt change of E f and no space charge — which is v far from reality. The best justifica of this simple gun is that it works. width of the cathode was chosen on basis of an available CW cur density of 3A/cm² for a beam cur of about 300 mA, and the cath length approximates that of a d

e finger. Experience with the large mber of tube models built for the oject gives assurance that the present ctron gun design is close to optiim.

agnet Design

In the X-band M-type backward-ve oscillator, the interaction space, ere a uniform magnetic field is eded, is rather narrow in radial rection over nearly the complete cirmference of the circular delay line igure 2). Advantage is taken of this t by using a toroidally-shaped permanent magnet (Figure 1) whose agnetic efficiency and self-shielding operties are believed to be superior those of more conventional shapes. e required size of this magnet is duced appreciably by placing fermagnetic material within the tube d covers, a procedure which shortens e air gap of the magnetic circuit. e flux density in the QK634 interion space is about 2800 gauss.

echanical Problems

Most of the special mechanical den efforts expended during developent of the QK634 arose from the cessarily small size of the parts reired for X-band tubes. Successful eration of this backward-wave oscilor results from the careful consideron of the following mechanical tors:

(a) Precise alignment of the two erleaved crowns of the interdigital e to form as nearly perfect a peric structure as possible.

(b) Accurate placement and retenn of the sole in its position relative the slow wave structure.

(c) Precise location of the electron n components with respect to each er and to the chief assemblies of tube.

K634 Operation and Characteristics

As in all microwave power generrs utilizing electron beam-rf wave eraction extended in space, bunch of the electron beam occurs in the kward-wave oscillator. This bunch increases progressively with disce and represents a high-frequency rent that induces waves of rf energy the delay line. This action is cumuve, and results in an rf wave travelalong the delay line with a group ocity opposite in direction to the velocity of the electron beam. The phase velocity of the rf wave, opposite in direction to its group velocity, has the direction and the approximate speed of the electron beam. During operation of the tube, potential energy is transferred from the electron beam to the rf wave, and the resultant rf power appears at the output finger or rf terminal of the delay line. This finger is the one nearest the electron gun, and is connected to the coaxial line leading to the external waveguide.

The rf frequency at which the QK-634 backward-wave tube oscillates depends on approximate synchronism between the electron beam velocity and the phase velocity of the rf wave on the delay line. The velocity of the electron beam, while it is in the interaction space, is controlled for tuning purposes by the electric field or potential between the delay line and the sole. Change of this potential alters the beam velocity, and such alteration is accomplished by a similar change in the phase velocity and hence frequency of the rf wave. Figure 6 shows typical power output, efficiency, and tuning characteristics of the QK-634.

In the QK634 tube, all dc potentials are referred to that of the cathode. The heater voltage is 10 volts, and the heater current is about 1.3 amperes. During normal CW operation, the voltage on the sole is maintained at —1600 volts, and the delay line potential is varied between about 2.35 and 5.15 kilovolts to tune the tube from 8150 to 11,000 Mc. Thus the tuning rate approximates one megacycle per volt of delay line potential change.

Although primarily intended for CW operation, the QK634 can be operated as a pulse tube at a variety of duty cycles and pulse durations. During such operation, the potential of the accelerator anode, an electrode of the electron gun, is altered to pulse the power output; the potentials of the other tube electrodes are maintained at their proper operating values. At pulse durations of either four or ten microseconds, peak power outputs about twice the power values shown in Figure 6 can be obtained. Because the tube is voltage-tunable, some attention must be given to the stability of the delay line and the sole voltages in effect during the pulse if rf spectral quality is important. Peak powers appreciably greater than those possible with the QK634 can certainly be obtained by means of a backward-wave oscillator, but the design of a tube specifically intended for pulse operation would differ markedly from that of the QK634.

The accelerator anode potential may also be varied to modulate the amplitude of the QK634 CW power output although, as with most types of oscillators, such modulation results in more distortion than can be tol-

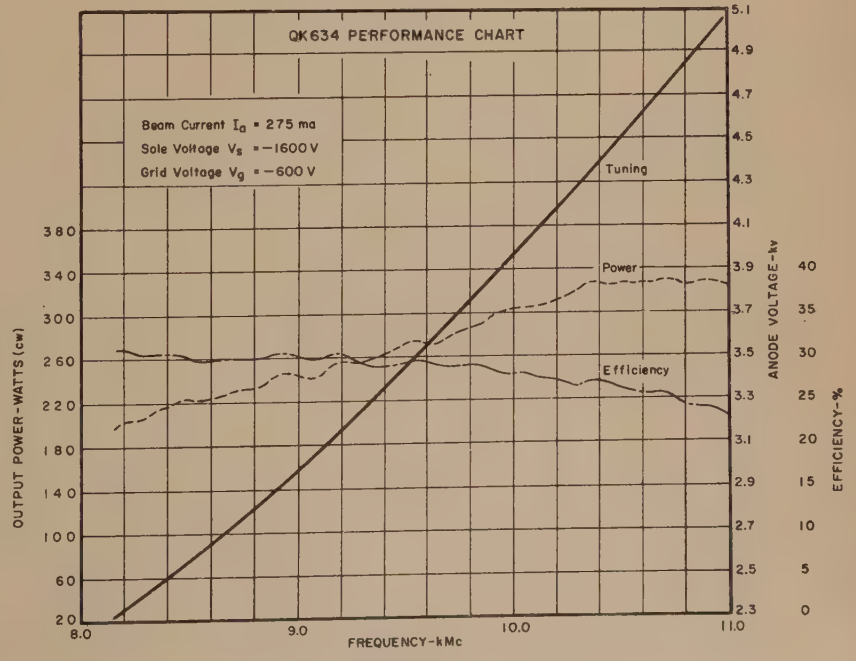


Figure 6

erated in a majority of applications. For 100% amplitude modulation of the QK634 output, about 550 volts rms must be applied to the accelerator anode.

By varying only the sole voltage, the QK634 can be frequency-modulated through about 200 Mc at any point in its tuning range. By readjusting the sole bias from its normal value, larger sole-tuned frequency intervals can be achieved, up to approximately 1000 Mc. Modulation rates as high as several megacycles per second have been effective. During frequency modulation, the frequency change is approximately one megacycle per volt of sole potential change.

With a 1.5/1 VSWR load the pulling figure of the average QK634 is about 12 Mc. In more than 50 QK634 tubes tested, the maximum pulling figure was 24 Mc.

The shift in QK634 carrier frequency which accompanies a change in electron beam current is termed "frequency pushing." It is measured by noting the output frequency change that occurs when the beam current is varied at a low audio rate. The average frequency pushing of the QK634 was found to be 0.36 Mc/ma at about 8200 Mc, a maximum of 0.40 Mc/ma near 8800 Mc, and approximately 0.26 Mc/ma at 11,000 Mc. As far as is presently known, frequency pushing values are always positive.

Other characteristics of the QK634 tube, such as thermal drift, noise output, and resistance to shock and vibration are now being investigated. Life tests are now in progress, and it is expected that an operating life of 1000 hours can be achieved.

Use of an M-type backward-wave oscillator to generate high levels of CW power at X-band frequencies is a relatively recent achievement, and the present QK634 tube is quite suitable for this purpose. This tube will be revised as needed, however, to take full advantage of the rapid progress being made in microwave techniques.

Acknowledgment

The continued and far-sighted support given by the U.S. Signal Corps and the U.S. Air Force to development of the QK634 and the earlier tube types of similar character is gratefu acknowledged, as are the signific contributions of Mr. Edward C. Den Mr. Russell T. Mannette, and ma other Raytheon engineers and te nicians.

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Footnotes

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[2] Fletcher, R., "A Broad-Band Interd tal Circuit for Use in Traveling-Wave T Amplifiers," Proc. IRE, Vol. 40, pp. 9 958, August, 1952.

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Broad Band, Multi-Port Waveguid Switches

Harry C. Berland • Fred W. Vortmei

Emerson Electric Manufacturing Company

Two types of high power, broad band waveguide switches have been developed for specific antenna scann systems:

The first switch is a high speed, single pole-five throw device which is used to switch the magnetron line each of five separate reflector-feed assemblies sequentially on a pulse to pulse basis. This sequential lobing ante system operates at a pulse recurrence rate of 1200 pulses per second, so that the switch must execute 1200 swi ings per second. The operating frequency band is 8500-9600 Mc/s. and the peak pulse power is 250 KW.

The second switch is a low speed, single pole-six throw device which is used to switch the magnetron between six individual antennas arranged equally spaced around a circle. One antenna is electrically connected to transmitter for 52 degrees of mount rotation, then blanked out for 8 degrees (dead time). The next antenna is t connected to the transmitter for 52 degrees azimuth rotation, etc. In this way, six scans per second are achie This switch also operates over the 8500-9600 Mc/s. band at 250 KW peak pulse power.

Introduction

Two types of high power, broad band waveguide switches have been developed for specific antenna scanning systems:

The first switch is a high speed, single pole-five throw device which is used to switch the magnetron line to each of five separate reflector-feed assemblies sequentially on a pulse to pulse basis. This sequential lobing antenna system operates at a pulse recurrence rate of 1200 pulses per second, so that the switch n execute 1200 switchings per second. The operating quency band is 8500-9600 Mc/s. and the peak p power is 250 KW.

The second switch is a low speed, single pole throw device which is used to switch the magnetron between six individual antennas arranged equally spa around a circle. The entire array rotates in azimut a rate of 60 rpm. One antenna is electrically conne

the transmitter for 52 degrees of mount rotation, ien blanked out for 8 degrees (dead time). The next ntenna is then connected to the transmitter for 52 egrees azimuth rotation, etc. The result is that a fixed ? degrees azimuth sector is illuminated by a sweeping eam moving from right to left, then the beam re- ppears at the right edge of the sector and repeats. In is way, six scans per second are achieved. This switch so operates over the 8500-9600 Mc/s. band at 250 KW eak pulse power. At a PRF of 1000 cps, approximately i4 pulses are transmitted during each antenna's on-time.

Basic Principle of the Broadband Switch:

Most microwave engineers are probably very familiar ith the short slot hybrid-dual TR tube balanced du- exer, and appreciate its inherent broadband features.[1] he principle of these rf switches is simply the parallel ldition of a number of short slot hybrid duplexers with etal movable shorting blades replacing the TR tubes. Figure 1 is a sketch intended to review the operation a pair of short slot hybrids with and without a etal shorting blade passed between them. In Figure a, the shorting blade is inserted and essentially all the power that enters arm A leaves by arm B. In gure 1-b, the blade has been removed and almost all the power now leaves by arm C. In these figures, the rows indicate direction of travel of the waves with db power splits at the dividing points. The correspond- g relative voltage phases are indicated along side the

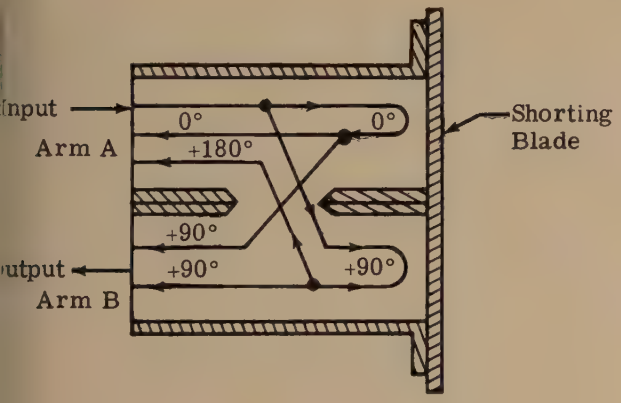


Figure 1a — Shorted hybrid.

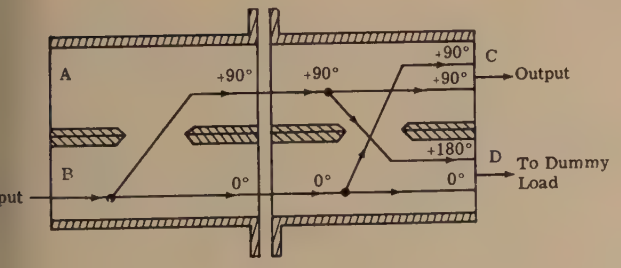


Figure 1b — Unshorted hybrid pair.

Short slot hybrid theory is explained by Henry J. Riblet in he Short Slot Hybrid Junction" Institute of Radio Engineers, l. 40, No. 2, February 1952, pp. 180-184.

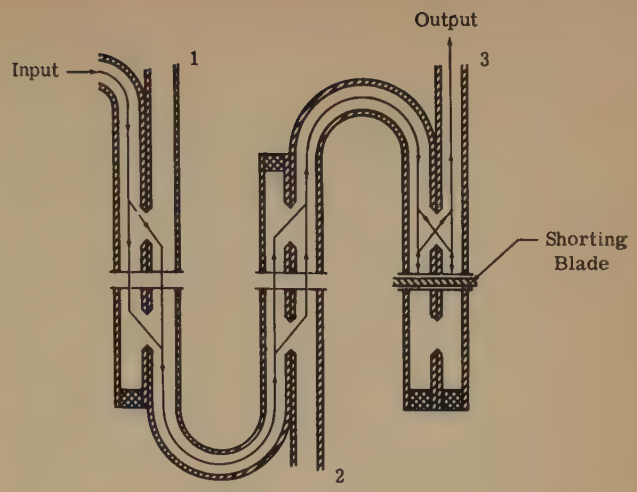


Figure 2a — Series arrangement of hybrid pairs.

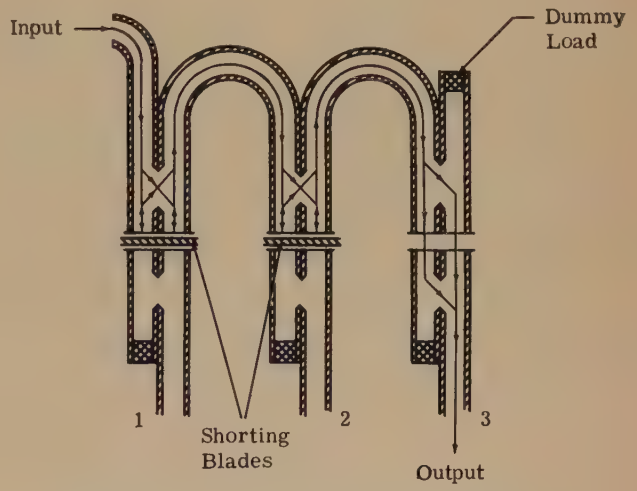


Figure 2b — Parallel arrangement of hybrid pairs.

proper arrows. In the arms where waves of equal voltage amplitude are 180 degrees out at phase, cancellation occurs.

Now, a number of these short slot hybrid pairs may be combined in a series or parallel arrangement as shown in Figures 2-a and 2-b. In the series arrangement of Figure 2-a, all shorting gaps must be open except one at any given transmission time. The transmitted wave progresses through the hybrids as indicated by the arrows in the drawing until the shorted hybrid is encountered. The wave leaves the switch via the output arm of the shorted hybrid. The same process is repeated for any other output arm desired by moving the shorting blade to the proper hybrid gap.

In the parallel arrangement shown in Figure 2-b, the exact opposite situation occurs: all gaps must be shorted except one. The wave progresses through the first hybrid, is reflected by the short circuit, and is subsequently reflected by each following shorted input hybrid until it encounters the input hybrid with the open gap. The wave then traverses this gap and leaves the switch via the output hybrid. Outputs are switched by moving the shorting blades so that another gap is open.

Of the two arrangements, the parallel combination is to be preferred for two reasons:

a. The insertion loss through an open gap is greater than that due to reflection from a shorted gap. In the parallel arrangement only one open gap is encountered, while in the series arrangement all gaps preceeding the shorted gap are open. Thus a lower insertion loss switch is possible using the parallel arrangement.

b. A small VSWR is incurred at an open gap, and hence a little power (about 24 db down) is reflected from the open gap. In the series arrangement, this re-reflected power emerges from each output port preceeding the port containing the shorted gap. This results in spurious radiation, only 24 db down, out of the antennas which are connected to these particular ports. In the parallel arrangement only one open gap is used, and the reflected power from this gap is absorbed in a dissipative load as shown in Figure 2-b. Hence the switch isolation is much better in the parallel arrangement.

II. High Speed Switch:

A. *Design Details:*

The high speed switch is required to switch 250 KW, one microsecond pulses between each of five separate antennas at a rate of 1200 switchings per second (one pulse out of each antenna in turn). After transmission of a pulse, that particular antenna must remain electrically connected to the input transmission line for a sufficient time to receive echo signals from maximum range targets. The operational bandwidth is 8500-9600 Mc/s. and the waveguide size is RG-51/U.

The switch performs three functions:

1. It switches the transmitter-receiver line successively to the five individual antenna feedhorns.
2. It generates the modulator trigger pulses to synchronize the transmitter pulses with the switch openings.
3. It generates reference pulses to synchronize signal processing circuitry with the lobing pattern for automatic antenna angle positioning (tracking).

As its first function the rotary switch serves as a microwave single pole-five throw switch. The rotor of the switch turns counter-clockwise, when viewed from the rear of the antenna, at a fixed rate of 4800 revolutions per minute. The rotor consists of a thin metal disc which contains three flanges (shorting blades), each 96° wi spaced 120° apart. The switch housing (stator) consi of two sections. Each section contains five short slot hybr spaced 72° apart.

The signal flow and operation of the switch can observed in Figure 3. The input high power pulse reflected from hybrid to hybrid until it encounters unshorted gap. The signal will then be transmitt through the open part of the switch blade, through hybrid on the other side, and then into the appropri antenna feed, in this case reflector 2.

In Figure 4-a, the waveguide shutter opening is sho transmitting the signal to reflector 1 waveguide. The an between the hybrid connected to reflector 1 wavegu and the hybrid connected to reflector 2 waveguide 144°, while the angle between shutter openings A and is 120°. Therefore, shutter opening B must move 24° align itself with reflector 2 hybrid. Shutter opening C m move 48°, or twice as far as B, to transmit through flector 3 hybrid. It can be seen that one of the shu openings is transmitting through an alternate reflector brid with every 24° of movement. This means that shutter openings are aligned with reflector hybrids 15 ti for each 360° revolution of the rotor. Since the roto turning at a fixed rate of 4800 revolutions per minute, 80 revolutions per second, shutter openings are alig with reflector hybrids 1200 times per second. Since o alternate reflector hybrids are aligned with shutter op ings, it can be seen that the operating order of the tennas must be 1, 2, 3, 4, 5. Figure 4-b shows the b rotated 24° ahead of that in Figure 4-a.

As its second function, the rotary switch serves a timer to pulse the transmitter 1200 times per second the rotor shutter openings and reflector hybrids are alig This is accomplished by a magnetic pickup which gener chain pulses in the following manner:

Fifteen small soft iron discs are imbedded in slots spa 24° apart around the periphery of the rotor. The rear the rotary switch housing contains a coaxial plug (Fig 4-a) enclosing a small coil and permanent magnet. the rotor turns, the discs cross lines of force set up

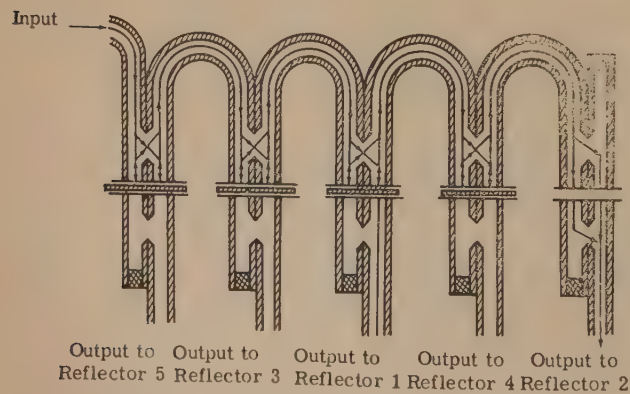


Figure 3 — High speed switch signal flow.

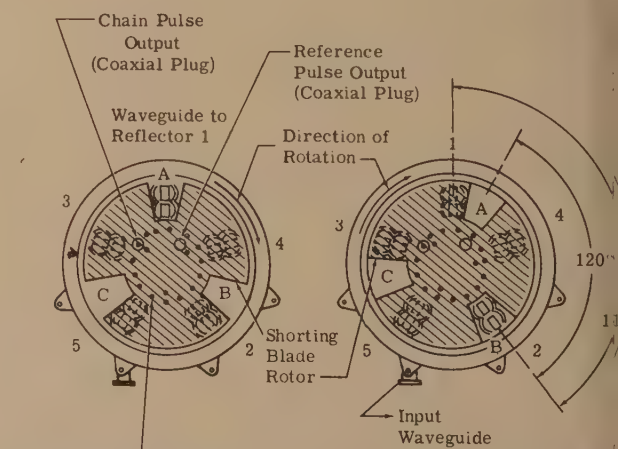

Chain Pulse Output (Coaxial Plug)
Reference Pulse Output (Coaxial Plug)
Waveguide to Reflector 1
Direction of Rotation
Shorting Blade Rotor
Input Waveguide
Soft Iron Plug (15 Spaced Equally Around Hub of Rotor. Every Fifth Plug Has An Index Plug)
Rotary Switch Viewed from Front of Reflector and Horn Assembly

Figure 4 — High speed switch cross section.

stationary magnet, inducing voltages in the stationary
kup coil. With the rotor turning at a rate of 80 revo-
ons per second, the 15 discs induce 1200 chain pulses
second in the pickup coil. In actual operation a trans-
ter pulse occurs as each rotor shutter opening ap-
aches alignment with an antenna hybrid, at approxi-
ely 1.6° before alignment. This allows sufficient time
a reflected radar pulse to return to the same reflector
back through the rotary switch to the receiver while
shutter opening is still nearly aligned with the antenna
rid.

s a third function, the rotary switch generates refer-
e pulses in a manner similar to the generation of the
n pulses, but at one fifth the PRF. The reference and
n pulses are utilized in obtaining target bearing in-
nation.

he critical design area concerns the shorting blade
s. The hybrids on the input side of the switch are
inated in dual broad band choke flanges of the UG-
./U type such as are used in balanced duplexers. The
ing flange on the output hybrid side of the gap is a
flat flange.

aboratory tests indicated that best results were ob-
ed in the gap-shorted position when the shorting blade
located 0.015 inches from the dual choke face. This
he standard gap distance for the UG-52A/U choke
ge. The 0.015 inch face projection outside the peri-
ry of the coaxial portion of the choke was removed so
the choke face was flush with the surface of the stator
. This allowed mechanical clearance between stator
and blade.

the open gap position tests revealed that the inser-
loss was minimized with a minimum thickness gap.
indicated that the rotating blade must be as thin as
hanically feasible, and the clearance gap between rotor
e rear face and the output hybrid flat flange be a min-
m consistant with mechanical clearance. A blade thick-
of 0.040 inches was selected, and a mechanical clear-
of 0.015 inches used behind the blade. This made
total gap 0.070 inches wide, or 0.055 inches wider
the UG-52A/U design. Insertion loss through this
is relatively small, less than .05 db over most of the
uency band. As an added precaution to reduce pos-
leakage through this open gap around the circum-
nce of the switch, polyiron plugs were placed flush
both input and output stator walls, equally spaced
ween hybrid centers.

he rotor blade rotates at 4800 rpm between stator
s with .015 inches clearance on either side. The rotor
e is manufactured flat within about .003 inches, and
difficulty has been experienced in field tests with blade
hanical interference. At this speed, the minimum ex-
ed bearing life without cleaning and relubrication is
0 hours.

Performance:

he electrical performance of the high speed switch is
marized below:

. Input VSWR: Figure 5 shows the input VSWR versus frequency for each of the five output ports connected to the input, with the shorting blade opening aligned with the center of each reflector hybrid. This data was taken with an automatic VSWR recorder. The VSWR looking through all ports is under 1.35 over the 8500-9600 Mc/s band.

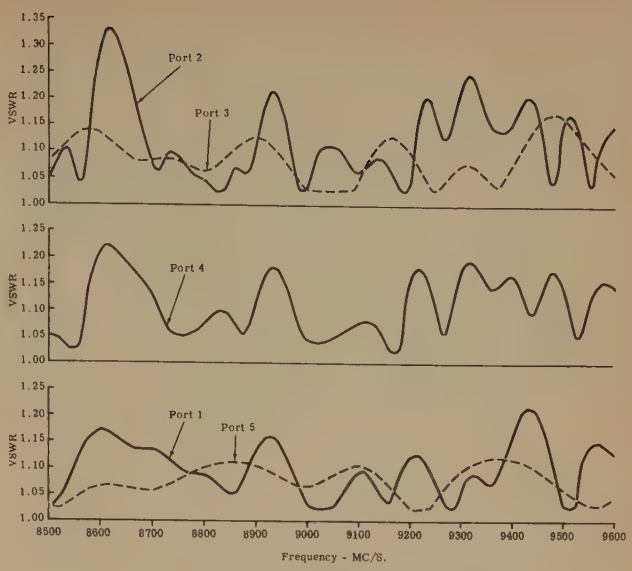


Figure 5 — High speed switch input VSWR for each output port energized.

Of particular interest is the graph of Figure 6 which shows the input VSWR as a function of rotor blade rotation at a fixed frequency of 9,000 Mc/s. This data was also taken with an automatic VSWR recorder, but in this case, the signal source was fixed tuned and the horizontal motion of the recording instrument was synchronized with the blade rotation by attaching a data pot to the gear train driving the rotor. Recording speed was one revolution of the rotor in 15 minutes.

Figure 6 clearly shows the VSWR spikes during the switching time and the low VSWR "vallies" occurring during the on-time. Since there are 15 switchings per revolution, the fifteen on-times shown are numbered with the corresponding output port numbers, one through five. The small letter a, b, or c following the port number refers to the particular blade opening envolved, since there are three openings in the blade. Notice the similarity in VSWR curves during the on-time of port 1 for blade openings a, b, and c, as well as those for the other ports. This is a good test of the mechanical symmetry and flatness of the rotor blade.

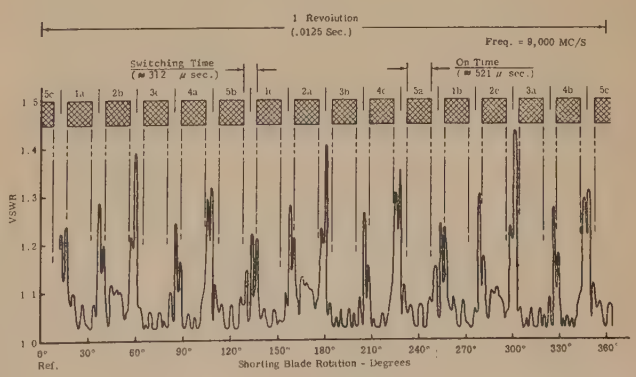


Figure 6 — Input VSWR VS. shorting blade rotation (high speed switch).

The horizontal scale is 15°/cm., showing that the usable on-time is about 1 cm, corresponding to approximately 512 microseconds on-time at the rated rpm. In the application for this switch only about the middle 20% of the on-time is utilized. The chain pulse is set to fire the transmitter when the blade opening is 1.6° in advance of center. The corresponding VSWR plots at other frequencies in the band are very similar to Figure 6.

2. Transmission and Cross Coupling:

Figure 7 is a composite plot of the energy emerging from each port as the rotor blade revolves. The data frequency is 9,000 Mc/s. The port and blade numbering is the same as in Figure 6. This data was taken with an automatic antenna pattern recorder, with the recorder horizontal axis again synchronized with the blade movement.

In this test a dynamic range of only —33 db was realized due to limitations on equipment sensitivity. As shown in this figure, there is no energy higher than —33 db emerging from any port when other ports are energized. The same results were obtained at other frequencies over the band.

The actual cross-coupling or isolation is much better than this, however. Table I gives the measured results using calibrated attenuators and a spectrum analyzer for ports 5, 2, and 1 at three frequencies. For any given port, a series of 12 isolation readings were taken, one reading for each of the other four ports energized with blade openings a, b, and c.

Only the minimum and maximum values of the 12 readings are shown. These readings indicate that the cross coupling is greater than 45 db.

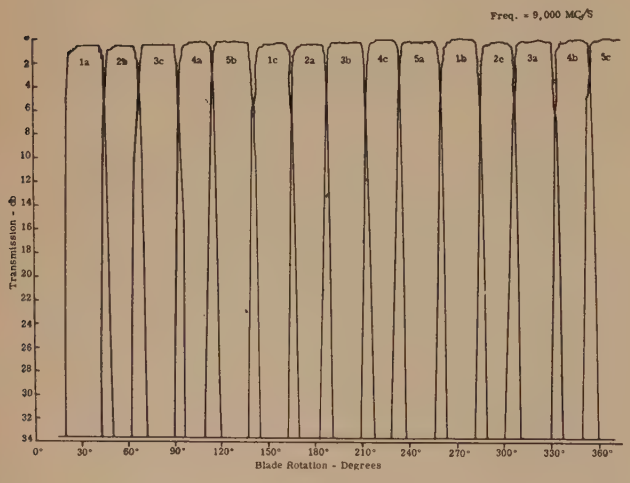


Figure 7 — Transmission through each output port (high speed switch).

TABLE I
Cross Coupling
High Speed Switch

Frequency Mc/s.	Port 5		Port 2		Port 1	
	Min. db	Max. db	Min. db	Max. db	Min. db	Max. db
8,550	46	80	47.5	76.2	45.9	67.1
9,000	47.3	60.5	51.3	64.3	53	55.9
9,600	46.4	64	53.7	63	46.2	69.2

3. Insertion Loss :

Table II gives the insertion loss through each output port at three frequencies. The measurement technique was the shorted line method given Page 819 of "Technique of Microwave Measurements," C. G. Montgomery, Volume 11 of the M Radiation Laboratory Series, McGraw Hill Bo Company Inc. New York, New York. This insertion loss measurement method yields losses exclusive reflection losses.

TABLE II
Insertion Loss, DB (Less Reflection Loss)
High Speed Switch

Port Number	Frequency: Mc/s.		
	8550	9000	9550
5	.227 db	.127 db	.072 db
3	.342	.212	.142
1	.37	.23	.245
4	.525	.35	.262
2	.687	.43	.30

The increased loss at 8550 Mc/s is due principa to increased rf choke losses and the loss in the op choke-flange shorting blade gap at the low freque end of the band.

C. *Mechanical Description:*

Figures 8-a and 8-b show two pictures of the comple switch. The shorting blade is made of an aluminum al and is mounted on a steel shaft which rotates at 4800 r inside a closed housing. This housing consists of t matched aluminum alloy castings 12-7/16 inches in ameter.

The shorting blade is driven by a 1/16 H.P., 220V, 4 cycle-three phase motor directly coupled to the blade sh The motor and interior housing are sealed to hold 15 p pressure. The shorting blade shaft is supported betw two radial bearings which are mounted in cages. To adj for blade clearance, the cages are shimmed on the housi forcing the blade to shift in an axial direction.

III. Low Speed Switch

A. *Design Details:*

The low speed switch is required to sequentially swi one input waveguide to each of six output waveguides continuous rotation at 60 rpm in either clockwise counterclockwise direction. The action of the switch mits switching of the energy into an output port dur 52° of rotation. The switching action or dead time tween consecutive output ports equals 8 degrees of sw

Figure 8a — View of input side — high speed switch.

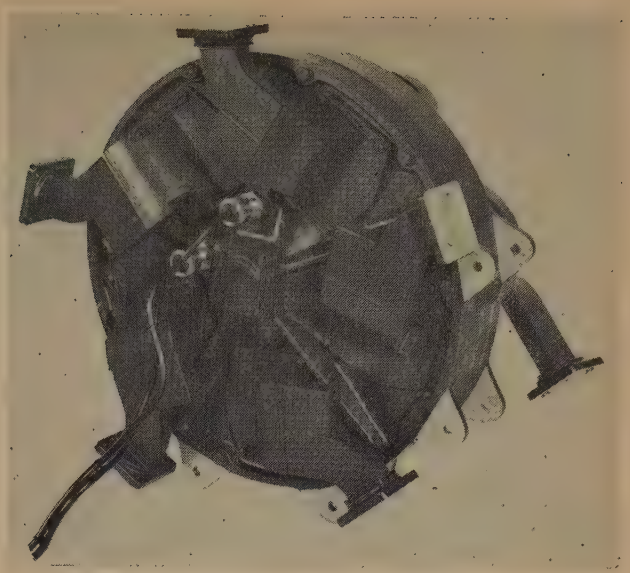


Figure 8b — View of output side — high speed switch.

otation. A timing device is incorporated to synchronize ne transmitter with switch openings.

The switch assembly includes provisions for supporting nd rotating a 600 pound antenna assembly coaxial with ne output waveguide ports. The switch therefore, con- ains an rf rotating joint, and the input and output hybrid ssemblies constitute the rotating portion of the assembly. he shorting blade between hybrid gaps is stationary. A eared device allows selection of any 52 degree azimuth ector throughout the 360 degrees of rotation. This sector election adjustment includes a calibrated dial and locking evice.

The major structure comprises 4 aluminum alloy cast- ngs and a steel shaft. All bearings are sealed and anti- riction. Seals isolate the inner chamber of the switch from he atmosphere, and the chamber and waveguides are apable of pressurized operation at 15 psig. Rotational rive is by silent chain. Figures 9-a, b show photographs of the completed switch.

The switch housing (rotor) consists of two sections. Each section contains six short slot hybrids spaced 60° apart. The stator shorting blade is a .040 inch thick metal disc with a single cutout in it 60° wide. Signal flow and operation are the same as that depicted in Figure 3 except a sixth port has been added.

Figures 10-a and 10-b are the ones corresponding to figures 4-a and b for the high speed switch. The view is that looking into the input side of the switch. In Figure 10-a the blade opening allows the input to feed antenna hybrid 1. Clockwise rotation of the hybrid rotor for an additional 52° will allow port 1 to be continually energized. Figure 10-b shows the hybrid rotor position rotated 52° clockwise from that shown in figure 10-a. At this point, the transmitter is turned off and blanked out for an additional 8° of rotor rotation. Then the transmitter is turned on again and port 2 is energized for the next

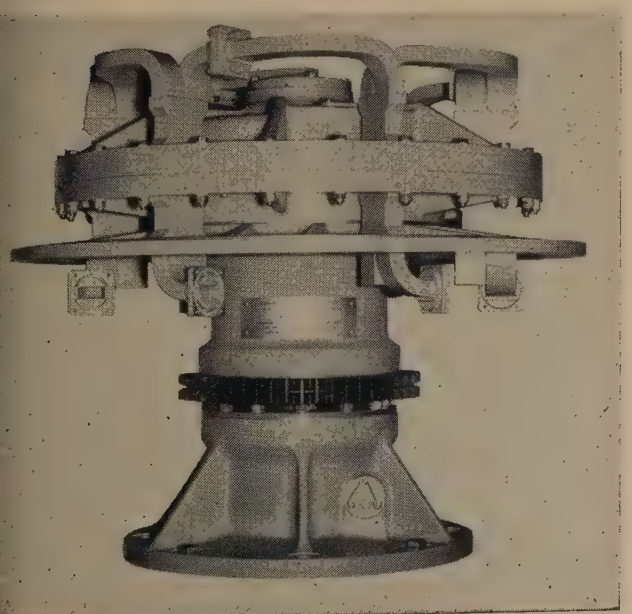


Figure 9a — Side view — low speed switch.

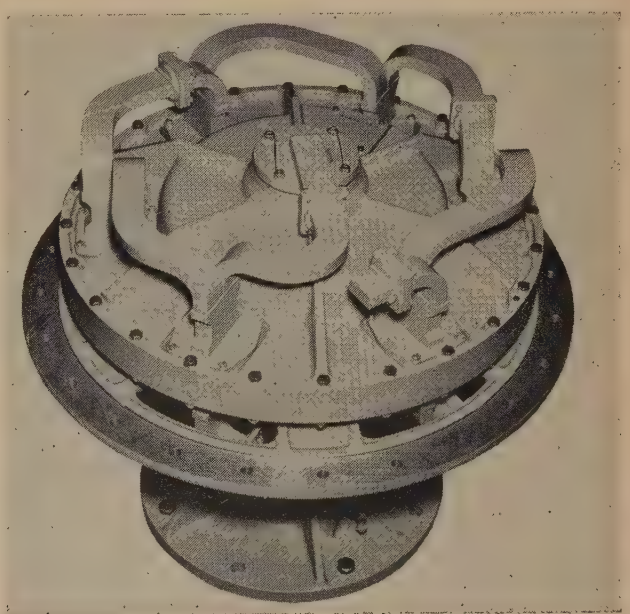


Figure 9b — Top view (input side) — low speed switch.

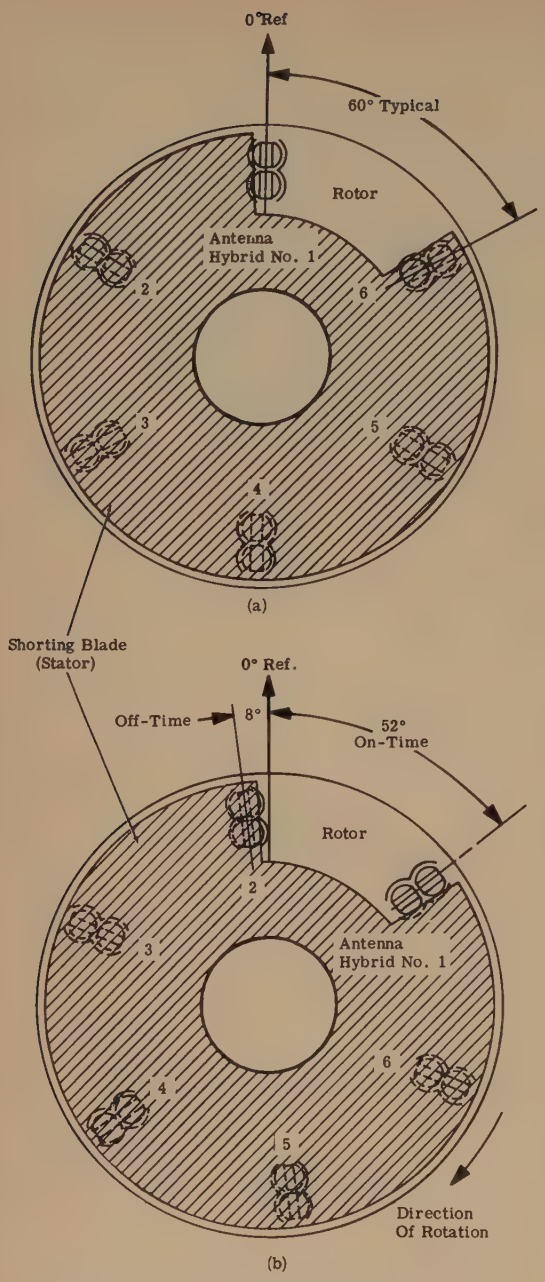


Figure 10 — Low speed switch cross section.

52° of rotor rotation. The same 52° azimuth sector is illuminated by the sweeping antenna beams at 6 scans per second. The azimuth illumination sector is changed by manually rotating the position of the shorting blade stator gap with respect to the switch mounting base by the worm and wheel arrangement described previously.

A design requirement of 52° minimum on-time had to be met, and the switch diameter held to a consistent minimum. For the given fixed dual choke flange dimensions (dual UG-52A/U), the ratio of on-time to off-time is maximized by increasing the switch diameter. The ultimate limitation concerns how far into the choke groove area the edge of the shorting blade can protrude before arcing occurs. This was determined experimentally and a switch diameter of 20 inches was chosen as the minimum diameter consistant with 52° on-time and a margin of safety for arcing.

To provide the synchronizing trigger for the modulator the following facts had to be taken into account: the synchronizing device must execute the switching from on time to off-time very rapidly. At 60 rpm the on-time is about .145 seconds and the off-time .022 seconds. The off-time cannot be reduced much because of waveguide arcing, while an increase in off-time cuts down the on-time angle to below 52°. The transition from on to off-time and visa-versa has to be limited to approximately one-half millisecond.

A Sylvania 1N77A photodiode and a grain of wheat light bulb are attached to the non-rotating member. A segmented light shield is a part of the rotating member. This circuit arrangement eliminates the need for slip rings and a consistant electrical switching time of less than one-half millisecond is obtained. When the light shield passes between the light source and photodiode, a 20 volt change in voltage is obtained. This produces a square wave of proper duty cycle suitable for actuating modulator trigger circuitry.

Dual choke flange gap dimensions and shorting blade thickness are the same as in the high speed switch design. Individual input hybrid assemblies are also identical, only the interconnecting waveguide arms being changed. The only difference in output hybrid assemblies is that 90° curved hybrids are used on the high speed switch for packaging reasons and straight hybrids are used on the low speed switch.

B. *Performance:*

The electrical performance of the low speed switch is summarized below:

1. Input VSWR: Figure 11 shows the VSWR versus frequency for a signal feeding through the pedestal waveguide assembly, rf rotating joint, and rf switch hybrids to each of the six output ports. The increased

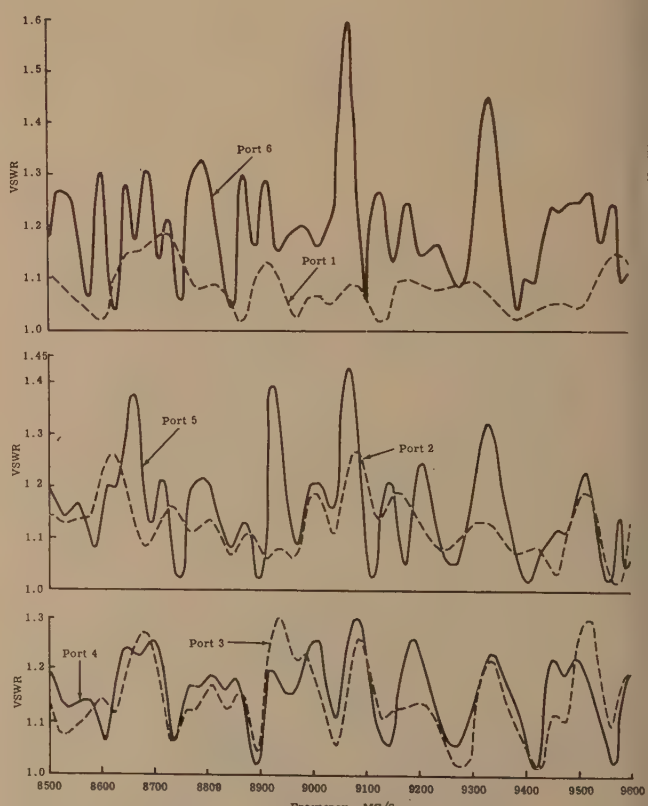


Figure 11 — Low speed switch input VSWR for each output port energized.

VSWR of this switch as compared to the high speed model is due to the greater number of waveguide components contributing reflections and the relatively greater distances between components. The VSWR of ports 1, 2, 3, and 4 does not exceed 1.3 over the 8500-9600 Mc/s band. Port 5 has a VSWR under 1.45, while port 6 is under 1.45 except for one spike with VSWR value of 1.6. The design specification called for a VSWR under 1.8 over 90% of the frequency band.

Figure 12 shows the VSWR of the entire switch versus mount rotation at a frequency of 9375 Mc/s. Similar plots over the frequency band reveal that the variation in VSWR throughout any output port on-time is less than 1.075.

2. Transmission and Cross Coupling:

Figure 13 is a composite plot of the energy emerging from each port as the mount revolves. The cross coupled energy out of each port during on-time is greater than —33 db, again the limit of recording equipment sensitivity. This data was taken at 9100 Mc/s., and the same results were obtained over the frequency band.

3. Insertion Loss:

Figure 14 gives the insertion loss less reflection loss vs. frequency for the entire switch assembly, including rf rotating joint, for each of the six output ports.

V. Discussion

The most appealing point about this type of switch design is the relative simplicity of the approach. The performance is predictable and constant over a wide range of environmental conditions. Furthermore, an almost unlimited number of combinations of switching actions, speeds, and number of output ports are possible. Two or more such switches may be combined with chopper switches which commutate the energy between them to satisfy requirements for more sophisticated scanning schemes.

There are no critical waveguide dimensions or resonant lengths in these switches, and the general design lends itself to reproduction in any frequency band and waveguide size. The most important waveguide items, the short slot hybrids, are precision castings, and the dual choke flanges may be cast also.

A switch of this kind is of the unsymmetrical type, i.e., the VSWR and insertion loss vary as different output ports are connected to the input. For this reason, the magnetron should be isolated by means of a ferrite isolator. Even if the switch did not exhibit this unsymmetrical property, an isolator would still be needed since the phase of the reflections from the several antennas probably could not be controlled over a wide frequency band.

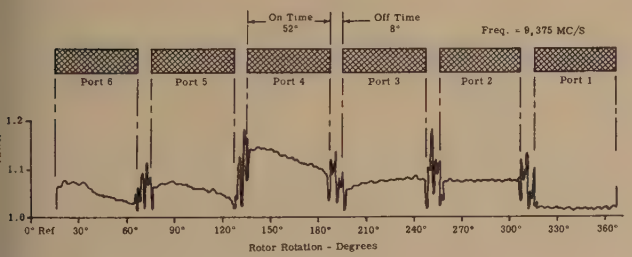


Figure 12 — Input USWR VS. rotor rotation, low speed switch.

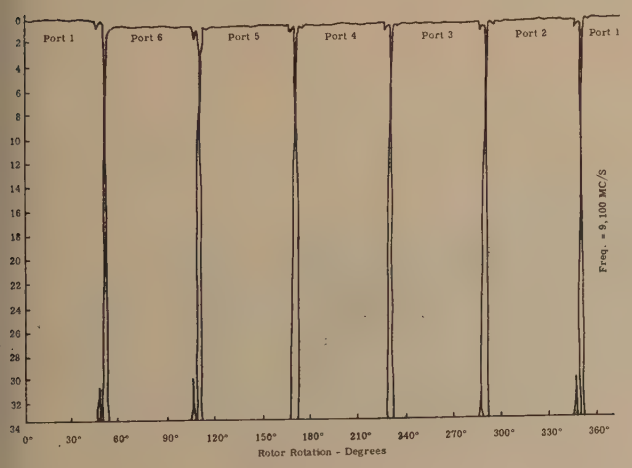


Figure 13 — Transmission through each output port (low speed switch).

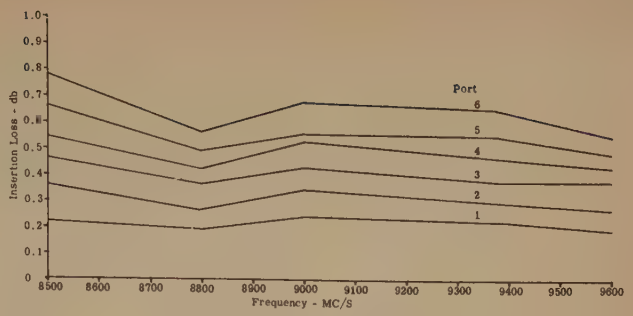


Figure 14 — Insertion loss (less reflection loss) low speed switch.

V. Historical Note

The original idea for the high speed switch was conceived at Emerson Electric in early 1953 for the U.S. Navy Electronic Laboratory, San Diego, California. Mr. W. L. Teeter, then with the Electromagnetics Division at N.E.L., demonstrated the feasibility of the approach by constructing an in-line model consisting of hybrids arranged in a straight line representing the series connection arrangement of Figure 2-a. The shorting blades were individual segments connected at regular intervals down a transmission shaft. Later a series connected rotary switch was constructed in RG-52/U size waveguide. These results were reported by Mr. Teeter in N.E.L. report 520, and in the October 1955 issue of the Transactions of the IRE, Professional Group on Microwave Theory and Techniques.

Later Emerson Electric was awarded a task by the U.S. Navy Bureau of Ships to develop a switch suitable for a specific system application. The high speed switch reported herein represents that effort, and the switch is now in production.

The low speed switch was developed by Emerson Electric for the U.S. Naval Air Missile Test Center, Point Mugu, California in 1958.

ABSTRACT
This paper describes the use of a novel device which can be used in concert with a standard slotted line to measu impedances rapidly. The classical method of measuring mpedance on a slotted line requires tedious mathematic manipulations to compute wavelength and minimum shift in fractions of a wavelength. These computations a accomplished mechanically by the slotted line attachment which provides the direct reading of wavelength sh with respect to a selected reference point. This data can thus be entered immediately on a Smith Chart. Exte sive laboratory use of this device has demonstrated its accuracy as well as its time-saving qualities.

A NOVEL AID TO SLOTTED LINE MEASUREMENTS

Bernard Lamberty

SYLVANIA ELECTRIC PRODUCTS, INC.
Electronic Defense Laboratory

The slotted line is generally recognized as being a very precise instrument for measurement of microwave transmission line characteristics. However, one of the most tedious tasks in connection with such measurements is that of measuring impedance over a wide frequency range. The recording of null positions, subtracting of distances between null positions, converting to wavelengths, measuring of null shift positions and converting again to wavelength shift involves considerable tabulation of data, subtraction processes and slide rule manipulations. In addition, keeping track of null shift directions, either toward the load or toward the generator, is a frequent cause of mistakes in a method already fraught with other sources of human error. Since a knowledge of impedance behavior is necessary in microwave work of every level from research and development through quality control and production testing, a technician trained in at least the rudiments of microwave theory is required to compute these impedances.

Various manufacturers have developed electronic instruments which overcome some of these difficulties. However, some of these instruments are too delicate to withstand rigorous laboratory and field handling. Consequently, frequent alignment and long periods in the instrument repair shop are generally required. In addition, the relatively high cost of the electronic measuring instruments prevents most laboratories from obtaining them in sufficient numbers. A need exists for a low-cost means of measuring impedance, while still retaining the basic precision of the classical slotted line method and the measurement speed of the electronic measuring instruments. This paper describes a novel device which virtually accomplishes these objectives.

At the Electronic Defense Laboratory, a solution to the impedance measurement difficulties was found in the development and use of a unique, completely mechanical and inexpensive device attachable to any slotted line. This "Slotted Line Attachment" reduces the time required to make impedance measurements by locating the angular position of the impedance on a Smith Chart automatically. No preliminary recording of null positions data or mathematical computations are necessary. Figure 1 is a photograph of a final model of this device attached to a Hewlett-Packard Slab Line Model #805A.

The heart of the Slotted Line Attachment is an expandable scale, two versions of which have been utilize namely a chart version and a spri version. A spring version model shown in Figure 1. At each measu ment frequency, the scale is expand so that its extremities are a ha wavelength apart as determined adjacent null positions on the slott line. The scale is divided in inc ments of .01 wavelength. Null sh in hundredths of a wavelength b tween a short circuited load and unknown load can be read direct from the expanded scale. After rea ing VSWR on a separate meter, t unknown impedance is entered direct on the Smith Chart.

In order to appreciate the adva tages of using the Slotted Line Attac ment, a comparison of the steps r quired in the classical method of mea uring impedance on a slotted li with the steps required using the a tachment is necessary.

For the classical method, the mea urement procedure is as follows:

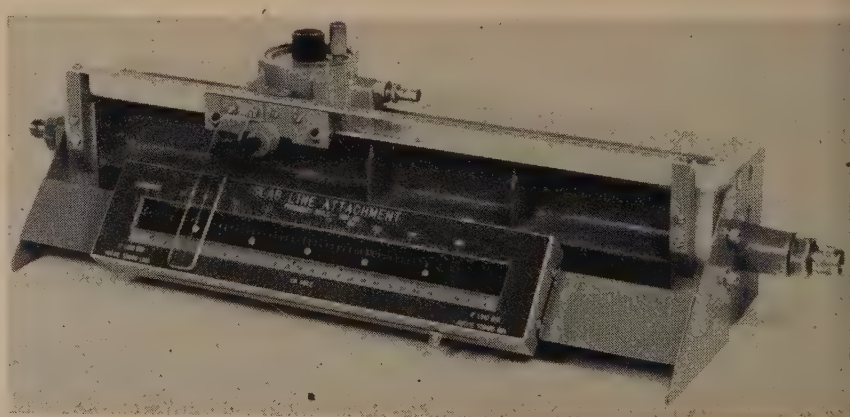


Figure 1 — Spring version, slotted line attachment.

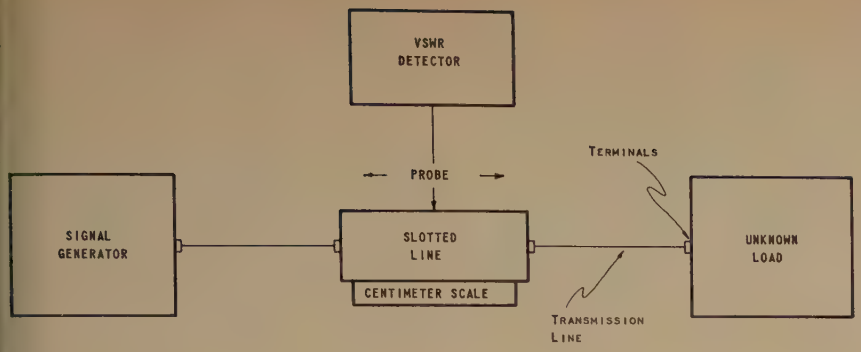


Figure 2 — Schematic diagram for slotted line impedance measurements.

a) The equipment is arranged as hown in Figure 2.

b) The generator is set at the esired frequency and the transmission ne is short circuited at the terminals o the unknown load.

c) Two adjacent minimum posi- ons are noted on the VSWR detector y sliding the probe along the slotted ne.

d) These positions observed in c) are recorded in centimeters.

e) Twice the value of the dif- erence in the two readings in (d) is ecorded. This value is the wavelength n the slotted line.

f) The short circuit is removed rom the terminals and the unknown oad attached. This generally causes he minimum position to shift from he short circuit minimum position. VSWR is read and a new minimum osition close to one of the short cir- uit minimum positions is recorded n centimeters.

g) The difference between the ninimum position in (f) and one of he minimum positions in (d) is ound. This is the value of minimum hift.

h) The ratio of the minimum hift found in (g) to wavelength ound in (e) is determined. This alue is the minimum shift in wave- engths.

i) A circle whose radius corre- ponds to the VSWR observed in (f) s drawn concentric with the center f the Smith Chart.

j) A position on this circle is ocated by rotating on the circle of (i) rom the zero resistance and reactance oint an angular distance correspond- ng to the value found in (h) and in direction toward the load if the min- mum shift in (g) is toward the gen- rator or toward the generator if the inimum shift is toward the load. The value of the unknown impedance an be read on the Smith Chart from the circles of constant resistance and constant reactance which pass through the plotted point.

A more detailed description of the Slotted Line Attachment is necessary to understand the measurement procedure used with it.

The chart version of the Slotted Line Attachment consists of a chart carriage, a guide bar, a pointer attached to the probe carriage, a viewing window, and a chart. These are assembled into a convenient unit which mounts on a slotted line. Each part will now be described.

The chart carriage consists of two rollers on which the chart is wound, much like the chart on a tube tester. The carriage is movable on the guide bar which is fixed to the slotted line (Figure 3).

The relative position of the probe of the slotted line is indicated by a pointer attached to the probe carriage and extending across the face of the chart. This pointer contains a hairline on a piece of transparent plexiglass (Figure 4) which is called the probe position indicator line.

A horizontal indicator line consisting of a hairline across the face of a plexiglass viewing window (Figures 4 and 5) remains fixed as the chart is turned beneath it. The viewing window is fixed to the chart carriage.

The chart itself is shown in Figure 6. This contains one or more frequency scales depending on the dominant mode supported by the slotted line. Across the face of the chart are two groups of diverging lines, one group on each side of a center reference line. Each of the groups contains three distinct sets of lines of different weights for interpolation purposes. The lines of the heaviest set are separated by a quarter wavelength at the frequency marked on the scale at the edge of the chart. The two remaining sets of lines, which are successively lighter, have separations of .05 and .01 wavelength respectively at the frequency

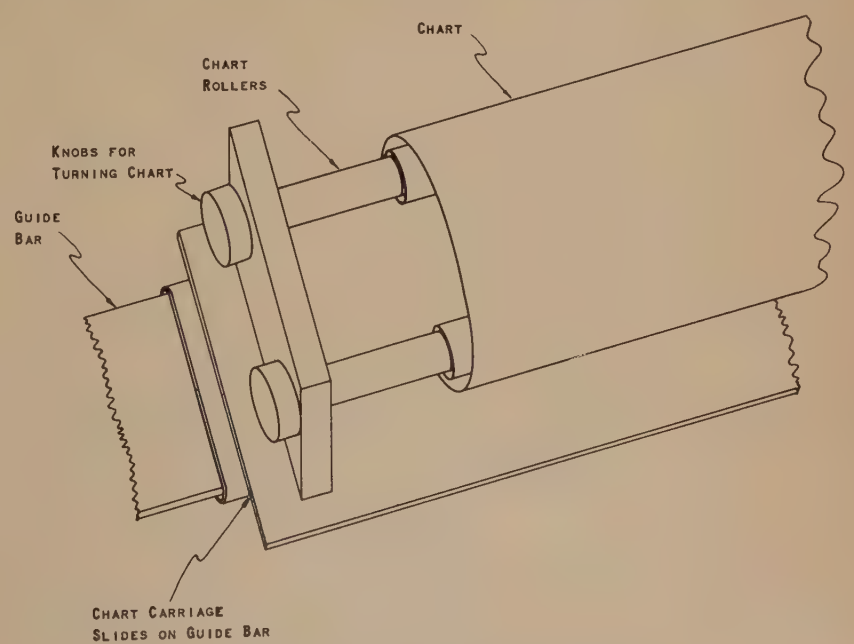


Figure 3 — Detail view of chart carriage.

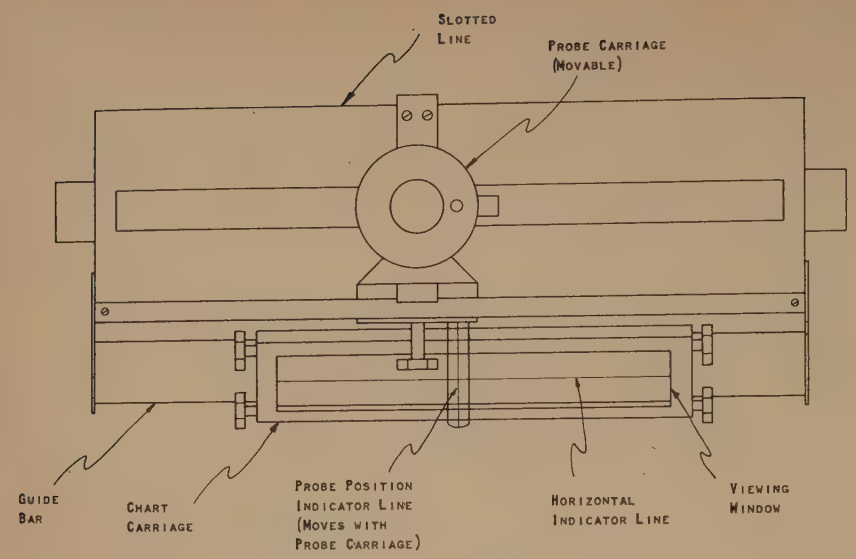


Figure 4 — Chart attachment mounted on a slotted line.

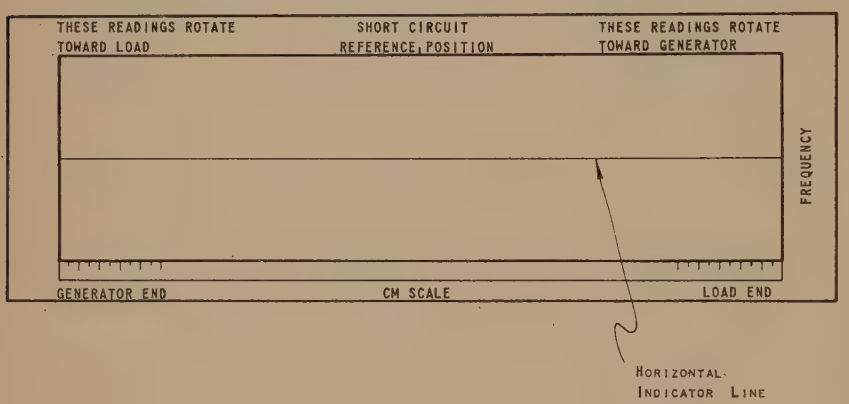


Figure 5 — Viewing window of the chart attachment.

Figure 6 — Center reference line chart.

marked at the chart edge. Visual i terpolation between the .01 wav length lines is possible. Increme of .05 wavelength are marked on t corresponding lines on either side the zero reference line at the center the chart.

Figure 7 is a photograph of t chart version of the Slotted Line A tachment fixed to a Hewlett-Packa #805A Slab Slotted Line. The pr cedure for measurement of impedan on a slotted line using this attachme is described below.

a) The equipment is again a ranged as shown in Figure 2.

b) The generator is set at the d sired frequency and the transmissio line is short circuited at the termina to the unknown load.

c) The probe is moved to a pos tion near the center of the slotted lin where a minimum reading is indicate on the VSWR detector.

d) The chart carriage is move along the slotted line on the guide b until the probe indicator line aligned with the chart center refe ence line. The chart carriage is locke in this position.

e) The probe carriage is move to an adjacent minimum point.

f) The chart is turned until on of the indexed half wavelength lin is at the intersection of the probe i dicator line and the horizontal ind cator line. Frequency can now be rea directly on the proper scale at the edg of the viewing window. The chart locked in this position.

g) The short circuit is remove from the terminals and the unknow load attached. VSWR is read and th probe carriage set at a new minimu position so that the probe position i dicator line is less than a half wav length from the chart center referenc line.

h) A circle whose radius corr sponds to the VSWR observed in (g is drawn concentric with the cent of the Smith Chart.

i) The value of the unknow impedance is located on the Smit Chart by rotating on the circle in (h from the zero resistance and reactan point an angular distance correspon ing to the reading on the chart at th intersection of the horizontal indicat line and the probe position indicat line. This reading gives the value

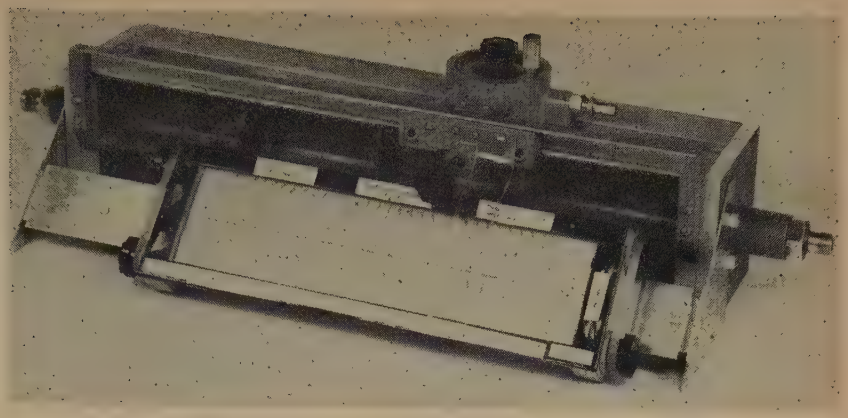


Figure 7 — Chart version, slotted line attachment.

inimum shift in fractions of a wave-ength directly. Notations on the view-ng window indicate if this rotation is oward the load or toward the gener-tor on the Smith Chart.

An examination of the above pro-edure, when compared with that of he classical method of measuring im-edance on a slotted line, shows that se of the chart version attachment has nany advantages. Among these are nore rapid measurement of impedance, o need for mathematical computa-ions, less chance of human error, and he capability of entering impedance alues directly on a Smith Chart with-ut first recording data. Use of this ttachment at the Electronic Defense aboratory reduces the time of meas-ring impedance over a band of fre-uencies by a factor of three.

A further simplification in the use f the chart, which has the advantages f doubling the frequency range over hich it can be used and reducing urther the possibility of human error, esults from the following considera-ions. The chart itself contains groups f lines on either side of the center eference line so that rotation of the mpedance point on the Smith Chart an be made either toward the load or oward the generator. However, for a iven test setup, rotation can be nade either always toward the load r always toward the generator by liminating the portion of the chart o the left (or right) of the center eference line. Then the reference line s translated to the left edge of the iewing window and the widest pos-ible separation between the half avelength lines is doubled for the ame chart size. The method of meas-rement is the same as that for the hart of Figure 6 except that null shift s always in the same direction with espect to the load.

An improved version of the Slotted Line Attachment uses a different type of expandable scale, namely a multi-turn, calibrated spring. This device is shown in Figure 1. A triangularly wound, 100 turn spring which stretches uniformly throughout a 10 to 1 expansion ratio is used as the expandable scale.[1] The separation between the zeroth and hundredth turn is set at a half wavelength at the operating frequency. The expandable spring mechanism is mounted in a carriage which replaces the chart carriage in the chart version of the Slotted Line Attachment.

The spring carriage contains the calibrated spring, a fixed support, a sliding support, guide rails, a spring locking mechanism, and a viewing window. The entire carriage slides along the same guide bar fixed to the slotted line as is used with the chart version of the Slotted Line Attachment.

The spring itself is color coded and indexed (Figures 8 and 9). Numbers corresponding to increments of .1 wavelength are fixed by means of metal tabs to every twentieth turn. Color coding on the other turns is such that turns corresponding to increments of .05 wavelength, .01 wavelength, and .005 wavelength are easily distinguishable. A triangularly wound spring was used so that the turns remain parallel and relatively upright. Also, each color coded part of the spring is a straight line.

The components described in the following are shown in Figure 8. The zeroth turn of the calibrated triangular spring is attached to a fixed support at the left side of the spring carriage. The hundredth turn is attached to a sliding support which can be translated

[1] The spring used is a replacement part for the Gerber Variable Scale Instrument, available from the Gerber Scientific Instrument Co., Hartford, Conn.

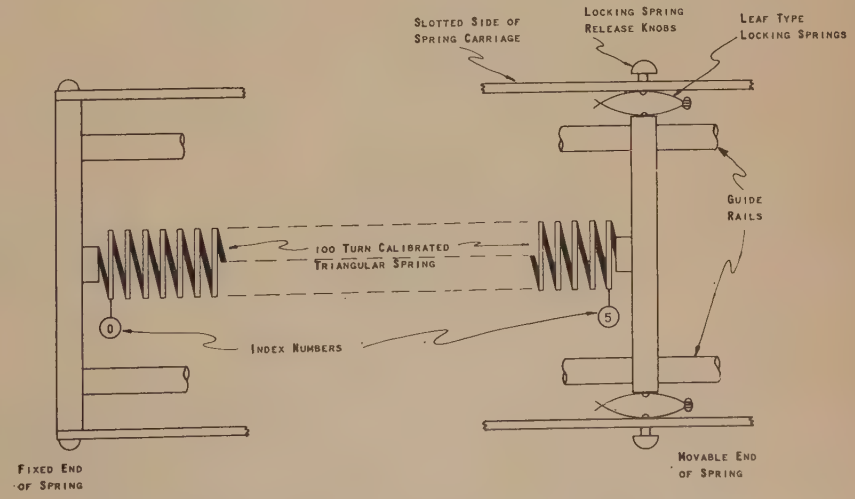


Figure 8 — Detail view of the triangular spring and carriage.

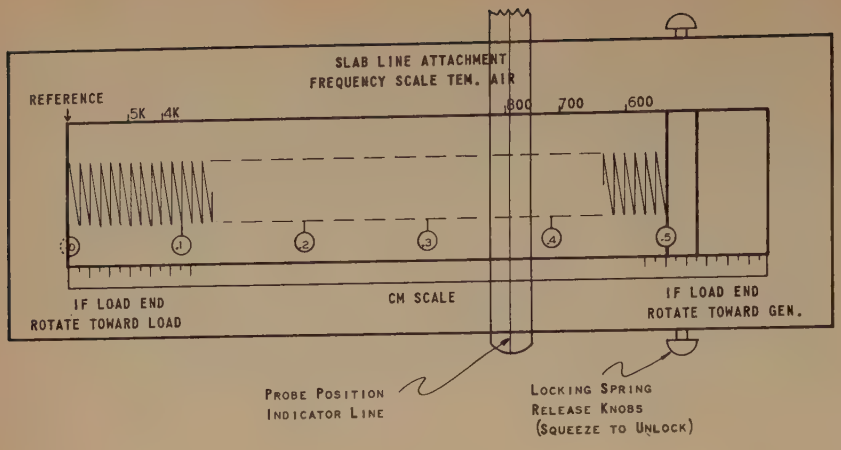


Figure 9 — Viewing window of the spring attachment.

along the two guide rails. The sliding support is normally held firmly in position to the sides of the spring carriage by means of an auxiliary leaf-type locking spring. The movable support is unlocked by squeezing the two locking spring release knobs together. When the hundredth turn is translated to the appropriate position, as described later, it locks in position when the knobs are released.

The viewing window is on the top cover of the spring carriage and is shown in Figure 9. This has one or more frequency scales at the top edge of the window and a centimeter scale below. Also indicated are appropriate directions for rotation on the Smith Chart and a reference end index mark.

The probe position indicator line is the same as that used with the chart version of the attachment.

The procedure for measurement of impedance using the spring version is the same as that using the chart version if steps d), f), g), and i) are replaced with the following:

d) The spring carriage is translated along the slotted line until the probe indicator line is aligned with the reference mark on the viewing window. This coincides with the zeroth turn of the calibrated spring. The chart carriage is locked in this position.

f) The calibrated spring is expanded so that the hundredth turn, corresponding to .5 wavelength, is aligned with the probe indicator line. Each turn of the calibrated spring then represents a multiple of .005 wavelength distance from the load reference point. Frequency can be read from the scale at the top of the viewing window at the position of the probe position indicator line.

g) The short circuit is removed from the terminals and the unknown load attached. VSWR is read and the probe carriage set at a new minimum position such that the probe position indicator line lies somewhere across the expanded spring.

i) The value of the unknown impedance is located on the Smith Chart by rotating on the circle in (h) from the zero resistance and reactance point an angular distance corresponding to the load minimum position shift. This null shift in fractions of a wavelength is read directly from the calibrated spring at the intersection of the spring and the probe position indicator line. Notations on the viewing window indicate if this rotation is toward the generator or toward the load on the Smith Chart.

The spring version of the Slotted Line Attachment has been found to be even more convenient to use than the chart attachment. Measurements can be made more rapidly and readings can be interpolated to values smaller than the nearest .005 wavelength. However, both versions are in use at EDL.

The chief advantages in using either version of the Slotted Line Attachment are:

1) The basic accuracy of slotted line measurements is very nearly retained.

2) The hundreds of necessary routine measurements of impedance in laboratories such as EDL can be accomplished in less than one third the time required by the classical method of measurements with less chance of operator error.

3) Its simple design assures reliable operation under rigorous handling conditions with little or no maintenance time required.

4) Cost of the attachment is small compared to the slotted line itself or compared to electronic impedance measuring instruments.

5) Impedance values over a band of frequencies can be measured by unskilled workers with a minimum of instruction.

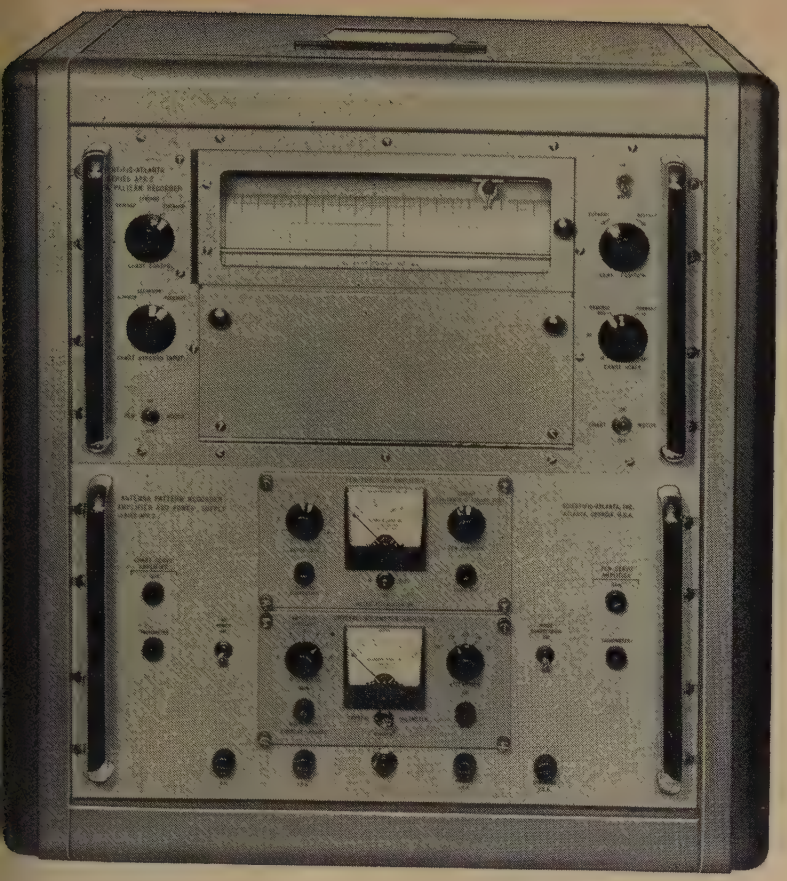
6) The device attaches to standard slotted lines with no modification required and without hindering the normal operation of the slotted line to which it is attached.

The chief disadvantages of both versions of the attachment are that measurements are not quite as accurate as those made by the classical slotted line measurement method and not quite as fast as those made with electronic instruments. The reason for the former is that the chart is not as accurate as the centimeter scale and the expansion of the spring is not exactly uniform. However, at EDL these inaccuracies have been found to be negligible. Furthermore, the reduction in operator error has more than compensated for the inaccuracies that exist. The latter disadvantage is offset by the relative cost of the two devices.

The helpful criticism of M. Blumberg and the mechanical features of the design by C. Harrison are gratefully acknowledged.

REPRINTS

Reprints of the ENTIRE TECHNICAL SECTION of "the microwave journal" may be obtained from the publisher at the following rates — 1 to 5 reprints, twenty-five cents each, 6 or more, fifteen cents each. Rates on reprints in large volume may be obtained on application to the publisher.



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** Noise suppressor for better S/N ratio * Bolometer burnout protector * DB meter for signal monitoring * Automatic single chart cycle advance*

Scientific-Atlanta's new series of rectangular antenna pattern recorders bring you new standards of performance, reliability and flexibility.

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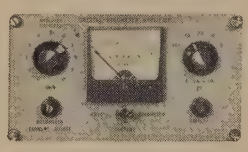
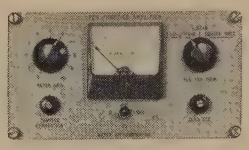


New high gain, low noise bolometer—crystal amplifier



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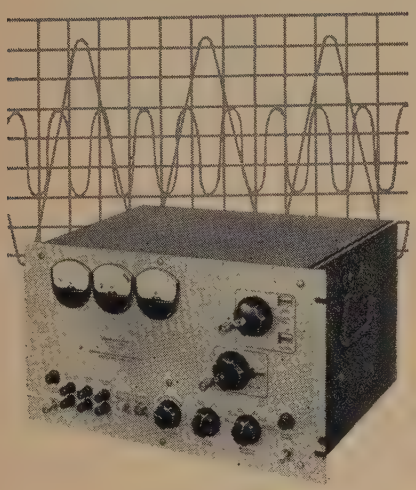

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The AIL Type 124C Power Oscillator is applicable as a signal source over the wide range of 200 to 2500 Mc. Its range, power and stability make it an essential element of microwave component test systems. It is often used in measurements relating to antenna design. Facilities for both internal and external modulation are provided. Relative power output is indicated directly on panel meter.

Detailed literature is available on request.

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HUNTINGTON STATION, L. I., N. Y.
A DIVISION OF CUTLER-HAMMER, INC.

Notes of the Industry

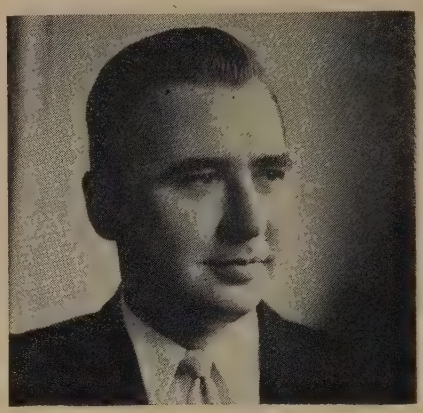
(*Continued from page 22*)

new RCA group, he had been a consulting scientist with the W. L. Maxson Corporation, New York, where he was concerned in major staff research studies in such fields as guidance, fire control, countermeasures, and radar map matching.

• • •

MICROWAVE ASSOCIATES, INC., APPOINTS NEW VICE PRESIDENT

Mr. Vess Chigas, Executive Vice President of Microwave Associates, Inc., announced the election of Dr. Lawrence Gould as a Vice President of the Corporation at a recent Board of Directors meeting.



Effective immediately, Dr. Gould has been promoted to fill the newly created post of Manager of Tube Operations. He will be responsible for all duplexer and power tube engineering and production, and will concentrate on the rapidly expanding microwave tube field with emphasis on the introduction of new products.

Dr. Gould has been with Microwave Associates since 1953 and headed the Duplexer Department prior to this appointment.

He received his B.S. and PhD. degrees in Physics from Massachusetts Institute of Technology in 1950 and 1954 respectively.

• • •

BURT J. BITTNER JOINS KAMAN AIRCRAFT CORP.

In announcing the acquisition of Mr. Bittner, Dr. K. W. Erickson, Vice President of Kaman and General Manager of the Nuclear Division, revealed the Division's intentions of entering into new fields associated with Mr. Bittner's background in space electronics, air-borne antennas, and microwave systems.

Prior to joining Kaman, Mr. Bittner was Vice President and Director of Advanced Development for C. G. Electronics Corporation, a Subsidiary of Gulton Industries, Incorporated. During his eight years at Sandia Corporation, he was a Division Supervisor in charge of radar and antenna designs including many specialized designs for telemetry applications in Atomic Energy field tests.

Mr. Bittner received his B.S. from Colorado State University in electrical engineering and received additional training under the Navy radar training program at Princeton, MIT, and NRL. He

for
ACCURACY
and
STABILITY

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S——————
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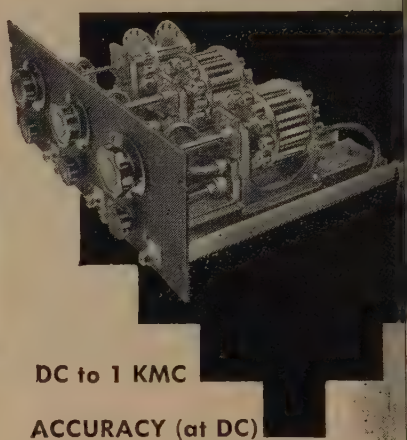
P————
ATTENUATORS



DC to 1 KMC

ACCURACY (at DC)
1 to 5 db: .02 dB
6 to 10 db: .05 dB
20 to 50 db: .10 db

RF CALIBRATION ACCURACY
1 to 30 db: .1 db
40 to 50 db: .2 db

We supply individual calibrations at 400 and 1000 MC and, upon request, at other frequencies.

ATTENUATION RANGE
MODEL 60
2 drums, 0-60 db in 1 db steps
MODEL 64
3 drums, 0-64 db in .1 db step
MODEL 640
3 drums, 0-110 db in 1 db ste

Impedance-50 ohms
Connectors-Female Type N

Long term repeatability and assured quality are a result of our experience in making coaxial attenuato with our own stable film resistors since 1947. Our facilities for attenuato calibration are the most accurate facilities available commercially.

Weinschel Fixed Coaxial Attenuators cover the frequency range of DC t 12 KMC.

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KENSINGTON, MARYLAND

continued graduate studies at MIT and the University of New Mexico.

The Nuclear Division will move to Colorado Springs as soon as their new plant is completed this fall.

• • •

DR. E. L. GINZTON NAMED BOARD CHAIRMAN AT VARIAN

Dr. Edward L. Ginzton has been elected chairman of the board of Varian Associates to fill the vacancy left by the recent death of Dr. Russell H. Varian.

Like his predecessor, Dr. Ginzton was one of the original founders of Varian Associates, Palo Alto electronics firm, and has served as a member of the board of directors and of key committees since the Company's inception in April, 1948. For the past several years he also was assistant to the late chairman of the board, Dr. Varian.

Dr. Ginzton is an internationally known scientist and is director of the microwave laboratory at Stanford University as well as professor of applied physics and electrical engineering.

Dr. Ginzton has been a member of Varian's executive committee for five years, a member of the technical policy committee for ten years, and of the salary and organization committee since 1956.

Dr. Ginzton is a Fellow of the Institute of Radio Engineers and a member of Sigma Xi, Tau Beta Pi and Eta Kappa Nu. For his contribution to high energy physics, Dr. Ginzton was awarded the 1958 Morris Liebmann Prize, the highest scientific honor given by the IRE.

NEW PRODUCTS

NEW CANOGA RADAR ANTENNA HAS ONLY ONE MOVING PART

A new X-Band Radar Antenna is announced by Underwood Corporation, Canoga Division, Van Nuys, California. Called the Model 8340, it is the latest development in a line of microwave antennas, pedestals, and associated drive mechanisms.

Designed for mobile use as a portion of a tactical weapons system, the Model 8340 X-Band Radar Antenna is fully ruggedized and will operate under the severest environmental conditions.

Electrical characteristics include operation over a frequency range of 8750 to 10,500 megacycles with a power handling capability of 300 kilowatts peak power if operated unpressurized. Standard polarization of the antenna feed is linear and is adjustable to any orientation. Models with circular polarization are also available. The unit can accommodate reflectors up to three feet in diameter, thus providing approximately 37 db gain at midband frequencies.

The design of this latest X-Band Radar Antenna also affords increased simplicity and reliability. By designing the r-f feed to be the rotors of the coaxial drive motor and reference generator, the number of moving parts has been reduced to one, thus eliminating all drive belts, gears and cams.

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NEW! THE MERCURY "10" SERIES TRIODE CAVITIES

10% tuning range

Fully standardized line for design and production . . . Frequency range from 225mc to top existing tube limits

DELIVERY—30 DAYS OR LESS!

Only JVM offers these outstanding engineering advancements—low cost standardized production—off-the-shelf availability—design flexibility and uniform performance.

Miniaturized MERCURY "10" cavities are precision engineered for restricted tuning range, minimum weight-frequency stability and temperature compensation. The "10" series includes 720 different cavities designed for maximum power and/or voltage ratings of a variety of tubes.

Call or write for engineering drawings and specifications.

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THE FINEST QUALITY BRASS AND ALUMINUM STANDARD WAVEGUIDE FLANGES in stock at Formcraft—all precision made to military standards. For rigid and flexible waveguides.

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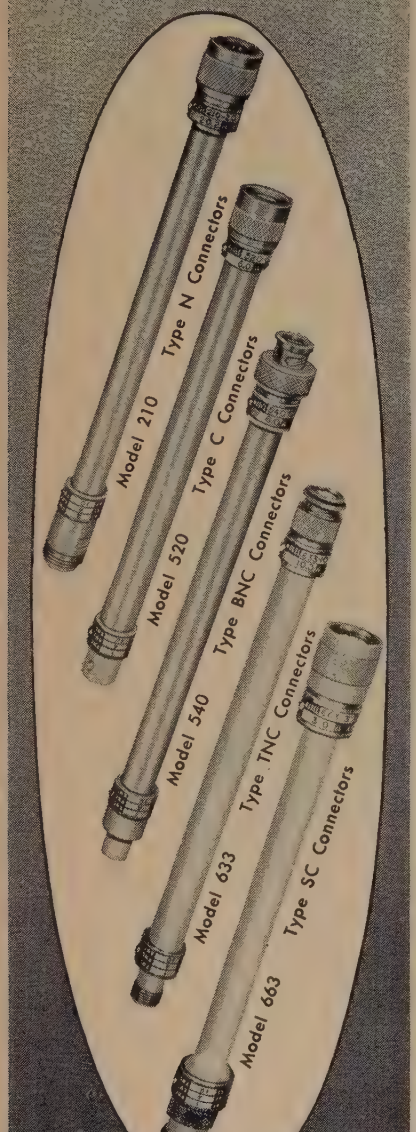
FIXED COAXIAL ATTENUATORS

1 to 12.4 KMC

50 Ohms 1 to 20 db

Connectors: Type N, C, BNC, TNC or SC. Each type with male/female, double male or double female connectors. Made with Weinschel Film Resistors for maximum stability.


Model 210 Type N Connectors
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Write for complete catalog, specifying frequency range of interest.

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In the field of microwave engineering, Wheeler Laboratories occupies a unique position as an independent laboratory devoted exclusively to consulting and development.

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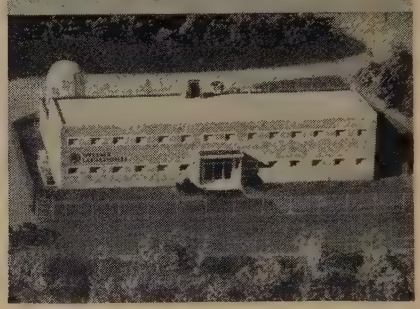


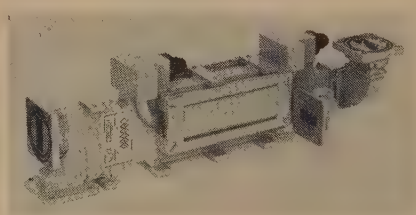
Antenna Laboratory and Test Range Smithtown, N.Y.

As a service to many prominent laboratories and manufacturers, WL has designed antennas, waveguide components, and microwave assemblies. Your inquiries are invited.

Harold A. Wheeler and Engineering Staff

CIRCLE READER SERVICE CARD 27

HIGH POWER X-BAND CIRCULATOR



The Rantec Corporation, Calabasas, California has developed its Model CXL 200 four port circulator. The new circulator operates in the frequency range 8.5 to 9.6 KMC, is capable of handling 1 megawatt of peak power and 1,000 watts of average power, and provides greater than 20 db of isolation with less than 0.5 db insertion loss. Designed to operate in an ambient temperature range of —55°C to 100°C, the new device may be pressurized up to 30 PSI gauge. The input and output mate with RG-68/U waveguide; length is 12 7/8 inches; and weight is 3 3/4 lbs. Provision for liquid cooling is provided for operation at maximum rated power level.

CIRCLE READER SERVICE CARD 102

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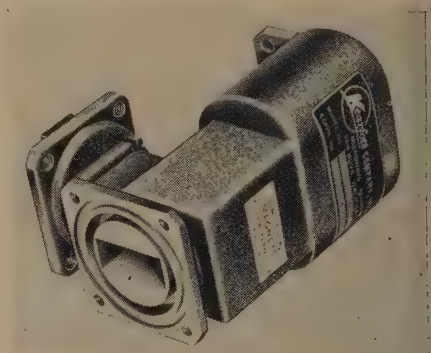
KEARFOTT MICROWAVE OFFERS NEW CIRCULATOR TEES

New light weight, compact Ferrite Circulator Tees offering exceptionally low insertion loss with high isolation have been developed by Kearfott Company, Inc., Microwave Division, Van Nuys, California.

By utilizing a ferrite resonant post technique with advanced design simplicity the new Tees are lighter, smaller and more easily packaged into confined-area microwave systems.



The new Circulator Tees are readily adaptable as a configuration for a modulator or fast-acting switch by replacing the magnet with an electromagnet. Additional isolation between specific arms can be achieved by adding a built-in ferrite isolator section. If required, further modification of the basic configuration can result in a 4-port circulator — with the 4th port used for a second signal input or other special needs.

CIRCLE READER SERVICE CARD 103

CIRCLE READER SERVICE CARD 28

RAYTHEON Ku-BAND FERRITE ISOLATOR

The Raytheon Manufacturing Company's Special Microwave Devices Subdivision, Waltham, Massachusetts, is now offering a low power Ku-band ferrite isolator designed to improve the performance of klystron excited systems.

The Model IKuL4 provides a minimum isolation of 25.0 db with an insertion loss of no more than 0.45 db across the band 16.0 KMC to 17.0 KMC. Maximum VSWR is 1.12.

The device is rated at 5 watts average power, weighs 2.9 ounces, and is 0.66 inches long.

CIRCLE READER SERVICE CARD 104

MINIATURE VHF BEACON

Lel, Inc. of Copiague, New York, announces the development of a miniature VHF beacon. The beacon may be used as an aircraft or drone crash locator, for signaling, control, and telemetering. The unit is crystal-controlled and utilizes three subminiature tubes which supply carrier output up to 100 mw in the 300 mc band. Complete with transistorized modulator-power supply, the beacon has an input requirement of 6 volts at 660 ma. Output impedance is 50 ohms and modulation is at 1000 cps. The beacon can be supplied on special order for any frequency in the range 220 to 320 mc using subminiature tubes or transistors throughout.

CIRCLE READER SERVICE CARD 105

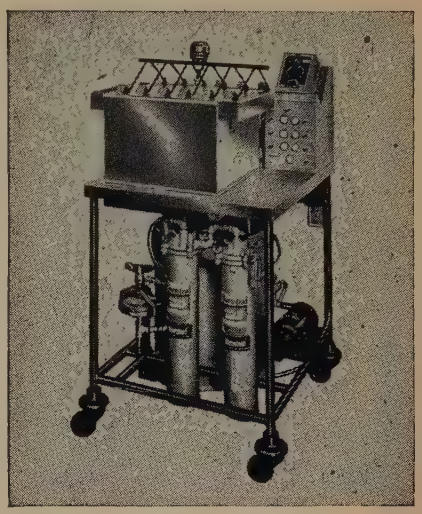
• • •

STAVID MAGNETRON PULSE TRANSFORMER

Stavid Engineering, Inc. of Plainfield, New Jersey, has developed a high-power

BARNSTEAD NEW TRANSISTOR WASHER

FOR WASHING and RINSING TRANSISTORS, DIODES, RECTIFIERS, TUBE PARTS and MATERIALS SUCH AS SILICON AND GERMANIUM



Maintains 15,000,000 OHM ultra-pure water while conserving make-up water through special re-purification cycle.

Best results with faster rinsing and fewer rejects are obtained when ultra-pure, hot water is employed in washing and rinsing of transistors, diodes, and other electronic components. The Barnstead Transistor Washer conserves thousands of gallons of water each day as it repurifies the pure, hot water keeping it free of organic impurities, and submicroscopic particles to 0.45 microns. Completely factory-assembled, ready for operation.

Partial Listing of Firms Using BARNSTEAD TRANSISTOR WASHERS

Clevite Transistor, Waltham, Mass.; Motorola, Inc., Phoenix, Arizona; Western Electric Co., Lauderdale, Pa.; Delco, Dayton, Ohio; Minneapolis-Honeywell, Brighton, Mass.; Bell Telephone Laboratories, Somerville, N. J.; Texas Instrument Co., Dallas, Texas and many others.

WRITE FOR CATALOG —

WATER STILLS, steam, gas and electric with capacities from ½ to 1000 g.p.h. **REGENERATIVE TYPE DEMINERALIZERS,** 50 to 2,500 or more g.p.h. **SUBMICRON FILTERS,** 400 or more g.p.h. Submicroscopic filtration to 0.45 microns

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First in Pure Water Since 1878

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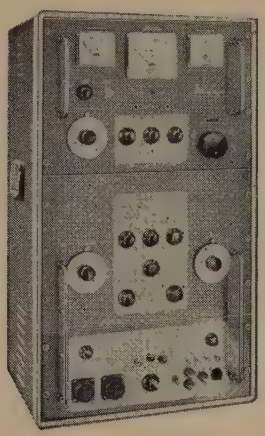

you need the NEW PRD 813

There is a "spanking" new BWO/TWT power supply that's really a work horse. PRD's latest contribution to the test equipment art, the Type 813 can supply just the right kind of power for driving a host of microwave tubes ranging from voltage-tuned magnetrons to travelling-wave amplifiers.

Featuring the latest advances, the PRD Type 813 has built-in time delays for filament and grid, delay line and collector, and anode voltages... and includes other frustration inhibitors, such as:

1. Individual adjustments of delay line, collector, anode, grid, and heater elements
2. Provisions for **both** internal and external sweep and amplitude modulation
3. AGC at the grid when used with external detectors
4. Digital read-out for delay line supply.

In addition to these features are the (typical of all PRD equipment) bedrock stability and high sensitivity of the first truly UNIVERSAL BWO/TWT Supply.

The remainder of the features and full specs for the PRD Type 813 can be yours by writing to: PRD—*first in microwaves.*

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CIRCLE READER SERVICE CARD 30

pulse transformer which features a plug-in magnetron receptacle and pulse cable connection. The unit's close tolerances permit direct connections with rigid magnetron mounts and control the depth of receptacle contacts. The transformer compartment within the case is completely sealed. The case contains two trigger windings to actuate external circuits, and an external expansion bellows and guard.

Specifications are as follows:
Power output: 1.3 megawatts at 28 KV.
Step-up ratio: 1: 3.5.
Primary impedance: 50 ohms.
Pulse deviation: 0.9 μsecs.
Pulse repetition rate: 1300 pps.
Filament supply: 3.5 amp.
Weight: 30 lbs.
Dimensions: 13" x 5½" x 8¼".
Terminal: 3".

CIRCLE READER SERVICE CARD 106

• • •

NARDA COMPONENTS FOR WR-159 AND WR-229 WAVEGUIDES

The Narda Microwave Corporation, Mineola, L.I., N.Y. has introduced a line of products for WR-159 and WR-229 waveguides. Engineered and manufactured to the same high standards and with similar specifications to Narda's standard catalog line, the new components include adaptors, detectors, impedance meters, low power terminations, sliding terminations, and slide screw tuners. Directional couplers for WR-229 waveguide are also available.

Specifications for these units, designed to cover the frequency bands 3300 to 4900 mc and 4900 to 7050 mc respectively, are identical to models covering adjoining waveguide sizes as described in Narda's standard catalog. Complete information on model numbers, prices, and specifications is available.

CIRCLE READER SERVICE CARD 107

• • •

NEW 3⅛ COAXIAL SWITCH BY ALFORD

The AMCI Type 1136 Coaxial Switch is a rugged and reliable new switch for 3⅛" rigid coaxial transmission line. It has a frequency range of 0-500 mc with a VSWR under 1.05.

The cw power rating of this switch is approximately that of 3⅛" coaxial transmission line.

The Type 1136 Coaxial Switch is available in both motor-driven and manually-operated models.

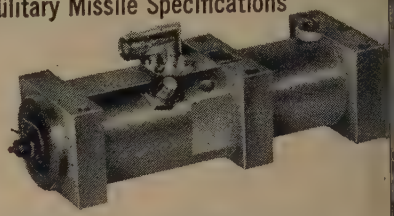
Crosstalk through the unused branch of the Type 1136 switch is over 60 db down at 80 mc, and over 40 db down at 500 mc.

CIRCLE READER SERVICE CARD 108

NEW!

S-Band *System-Tested* MICROWAVE COMPONENTS

Engineered to meet complete Military Missile Specifications



S-BAND PULSE OSCILLATOR

- Minimum 1.5 KW Peak Power Output at .001 duty cycle; 1 μsec pulsewidth 1000 pps
- 300 MC Tuning Range
- Operating Conditions: 3000V at 2.5 amp peak (nominal)

S-BAND CW OSCILLATOR

- Minimum 50 mw Power Output 100 mw at lower frequencies
- Exceeds 400 MC Tuning Range
- Operating Conditions: 125V-250V at approx. 20-35 ma depending on plate voltage.

Both oscillators are lightweight (only 20 oz.) with integrated mountings. Both use 6442 triode tube. Heater 6.3V AC or DC.

S-BAND FILTER-MIXER-DIPLEXER

- Mixer and Diplexer (non-tunable) operate as an integral part of the Filter
- Unit features minimum Insertion Loss, Rejection Bandwidth and Input VSWR.
- Tuning Range: exceeds 300 MC

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K-BAND MINIATURE WAVEGUIDE SWITCH

A new "Delta" micro-miniature waveguide switch has just been developed by Don-Lan Electronics Inc., Santa Monica, Calif.

Commercial applications for the design have included use in very-high-frequency relay stations and in general communications equipment.

RF power rating of the unit is equal to associated waveguide. The unique design achieves RF switching under power with a maximum VSWR of 2.1/1.0 during the switching cycle, and 1.2/1.0 max. in either position over the entire frequency range.

Designed for the "K" band — 12.4 to 18.0 KMC — the new "Delta" waveguide switch is remotely controlled to provide a highly reliable means of switching a single waveguide input to either of two outputs.

Other features include switching time of only .007 seconds and isolation of 40 db down as a guaranteed minimum. The new model W-6KS waveguide switch is priced at $285.00, with quantity prices available.

CIRCLE READER SERVICE CARD 109

• • •

TURRET ATTENUATOR FEATURES LOW INSERTION LOSS

A new line of turret attenuators for RF testing and instrumentation is now being produced by Telonic Industries, Inc., Beech Grove, Indiana. The units feature extremely low insertion loss up to 900 mc, low VSWR, and high accuracy in all attenuator positions.

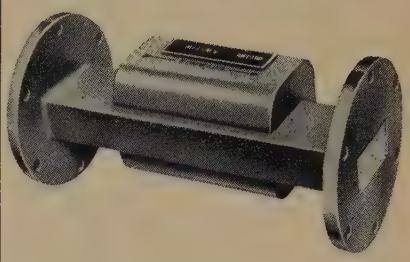
Representative of the new series is the Telonic TA-50 Turret Attenuator, which provides 0, 10, 20, 30, 40 or 50 db values of attenuation by turning a six-position switch. The unit is equipped with an attractive knob and dial assembly of black anodized aluminum and plastic. The Attenuator may be mounted by simply drilling three holes, one for the shaft and two for mounting screws, using a template supplied with the unit.

Telonic Turret Attenuators may be used separately as laboratory and production-line test elements, or as component parts of propriety RF test instruments.

Other Telonic Turret Attenuators in the

(*Continued on page 50*)

NEW WAVEGUIDE FERRITE ISOLATORS



Specially designed to offer maximum isolation with minimum insertion loss, six broadband isolators cover a frequency range of 3.95 to 26.5 KMC/S.

Conservatively rated at 5 watts, these rugged units can dissipate FIVE TIMES as much power with only temporary electrical characteristic degradation.

PRD TYPE	FREQUENCY (KMC/S)	MINIMUM ISOLATION	LENGTH (INCHES)
1205	3.95-5.85	16 db	8¼
1204	5.85-8.20	20 db	6⅛
1206	7.05-10.0	24 db	5
1203	8.20-12.4	30 db	6¼
1208	12.4-18.0	24 db	6
1209F1	18.0-26.5	24 db	4½

Complete specifications on the PRD Type 1203, 1204, and 1205 are contained on page A-21 of the PRD Catalog E-8. For a copy of this 160 page designers' workbook containing data on hundreds of quality microwave instruments from PRD, the company that's FIRST IN MICROWAVES, send your request on your company letterhead please.

If you want specifications on PRD Waveguide Ferrite Isolators, simply fill out inquiry card in this magazine.

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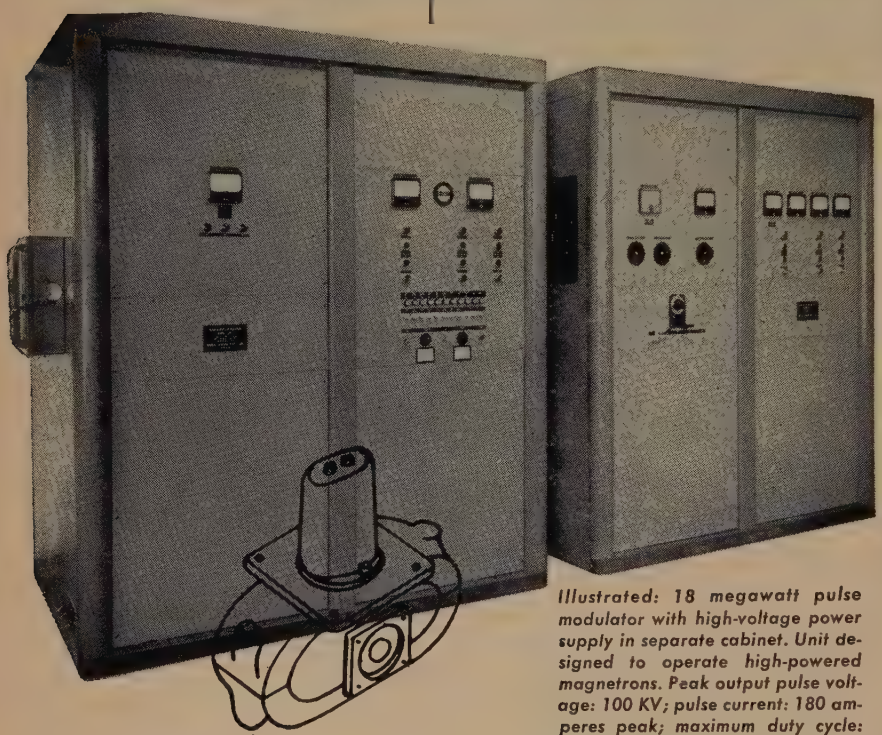
ULster 2-6800
Western Sales Office:
2639 So. La Cienega Blvd., Los Angeles 34, Calif.
TExas 0-1940

CIRCLE READER SERVICE CARD 33

Testing MAGNETRONS KLYSTRONS CARCINOTRONS

● OTHER MICROWAVE TUBES, COMPONENTS OR SYSTEMS?



Illustrated: 18 megawatt pulse modulator with high-voltage power supply in separate cabinet. Unit designed to operate high-powered magnetrons. Peak output pulse voltage: 100 KV; pulse current: 180 amperes peak; maximum duty cycle: .001; pulse widths: 2, 4 and 6 μsec.

Come to Manson for the widest selection of standard *Pulse Modulators* and *High-Voltage Power Supplies* covering all useful power levels. From kilowatts to tens of megawatts, Manson has precision-engineered designs for operation and test of magnetrons, klystrons, traveling wave tubes, backward wave oscillators, lighthouse tubes, pulse transformers, waveguide components and related devices. The wide range of standard models is readily adaptable to meet individual specifications.

HIGH POWER PULSE MODULATORS:

Hard- and soft-tube types from 16 kw. to 30 megawatts peak power output, and higher. Average output powers as high as 60 kilowatts. Typical operating features include: continuously adjustable voltage control; discrete or variable pulse widths; internally- and externally-controllable repetition frequencies; auxiliary synchronized outputs; pulse-shape monitoring circuits; and interlocking and overload protection.

HIGH VOLTAGE POWER SUPPLIES:

High-voltage DC and AC types, single- or multiple-output, regulations and stabilities to 0.01%. Standard and custom designs to satisfy your specific tube testing or production problems: highly-regulated supplies uniquely suited for TWT test and operation; unregulated high-power supplies for systems testing; and complete power sources for controlling all aspects of tube production.

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CIRCLE READER SERVICE CARD 34

line provide 0, 1, 2, 3, 4, 5 db, 0, 2, 4, 8, 10 db, and 0, 5, 10, 15, 20, 25 db, lowing the designer a wide latitude selecting attenuation ranges. The ur may be used singly or in series, each w its own control knob.

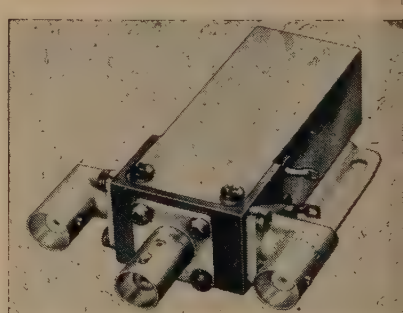
Insertion loss for the Telonic units essentially zero up to 200 mc, 0.1 db 500 mc, and 0.2 db to 900 mc, when me ured in the 0 db position. Accuracy 2% to 200 mc and 2% ± 0.5 db 900 mc. VSWR is 1.1-to-1 to 300 mc a less than 1.5-to-1 to 900 mc. Impedar is constant at 50 ohms for all attenuat positions.

The Telonic units are sturdily and co pactly built, the Attenuator body in ea case measuring 2 ¼ by 1 ¾ inches. Sil plated contacts assure highly relia switching even under production-line t conditions. BNC connectors are provid

CIRCLE READER SERVICE CARD 1

● ● ●

NEW JAMES COAXIAL CHOPPER INSENSITIVE TO SHOCK AND VIBRATION



A new line of coaxial choppers corporating a unique patented cen pivot reed construction for dynamic c cellation of external effects of shock a vibration is now available from Jam Vibrapowr Company, 4050 N. Rockw St., Chicago 18, Ill. The units may used for continuous or asynchron switching of coaxial signals. The drivi frequency can be D.C. to 175 c.p switching frequency can be D.C. to 5 MC. The unique design is available various configurations and types.

A new catalog page giving compl electrical and mechanical specifications the new James coaxial choppers is n available without cost.

CIRCLE READER SERVICE CARD

More NEW PRODUCTS *on page 5*

Opportunities at Hughes in

microwave research and development

Modern electronic systems demand a broad range of technical competence. The Hughes Microwave Laboratory has unusually extensive capabilities in the antenna, microwave component, and radome fields. Its activities are co-ordinated in a balanced program of fundamental research, development, design and production engineering.

ANTENNA RESEARCH—Included in current studies are: electronic scanning, its information transfer functions, and its relationship to system performance; surface waves and conformal surface antennas potentially useful on nose cones or low silhouette applications; and the theoretical aspects of transmission through small radomes.

ELECTRONICS RESEARCH—These investigations are concerned with basic phenomena such as amplification, harmonic generation, limiting and switching with ferromagnetic and dielectric materials, and superconduction in thin films at microwave frequencies.

MATERIALS RESEARCH—In the fields of Solid State Chemistry and Physics, studies are directed toward the synthesis and characterization of organic and inorganic compounds; new polymer systems; structural and electronic ceramics; and ferroelectric, ferrimagnetic and paramagnetic materials for electronic applications.

MICROWAVE ENGINEERING—the products of research are converted into advanced components, processes, and techniques for ultimate system application. Novel antennas, radomes, filters, and ferrite devices are being developed for the entire microwave and UHF spectra. New materials and processes are exploited for the production of ferrites and garnets, silicone plastics, ablative materials, high-temperature insulating and encapsulating materials, and electroluminescent panels. Research and engineering ideas are rapidly embodied in concrete forms through the facilities provided by a versatile design staff and a well-equipped shop.

Openings exist in each of the above areas. These positions offer excellent opportunities for qualified personnel in the fields of Physics, Chemistry and Engineering (Electrical—Microwave—Mechanical).

Please write: Mr. R. A. Martin, Supervisor, Scientific Employment
HUGHES RESEARCH AND DEVELOPMENT LABORATORIES
R and D Personnel Department, Culver City 52, California

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A. X-Band Reciprocal Ferrite Phase-Shift Experimental Electronic Scanner

B. Close-up of Hughes Ferrite Amplifier

C. Apparatus for X-Raying Single Xtal Ferrites and Garnets

CIRCULATORS

Basically, the Rantec circulator is a non-reciprocal hybrid junction with three or more ports. Non-basically, the circulator is finding more and more use in advanced radar and microwave systems. As an example, it has become an important component in maser and parametric amplifier systems in addition to its uses in duplexing circuits, in channel branching, as a high performance load isolator and as a low-loss directional coupler. The Rantec circulator is available in three types – *Rotational, Phase Shift* and *Tee* – all of which are small, lightweight, rugged and insensitive to stray magnetic fields. Rantec research and development has also led to many other sophisticated "*active*" and "*passive*" microwave ferrite components – *high-speed ferrite switches, single side-band modulators, amplitude modulators* and a number of *load isolators.* Your inquiry is welcomed.

rantec

corporation
calabasas, california

CIRCLE READER SERVICE CARD 35

New Products (Continued

UNIQUE METHOD SIMPLIFIES MICROWAVE PULSE POWER MEASUREMENT

Developed by General Communicati Company, Boston, the PCS-1 Pulse Pow Calibrator is a precision instrument f measuring the instantaneous power pulsed radio frequency energy. Labo tory performance is assured at all tim and simplicity of operation makes the strument adaptable to the production li

The method employed is unique, p mitting greater accuracy than heretofo obtained even by calorimetric means. establishes a measurement reference le at the time of each use. Ease of operati is assured by direct reading of pow measurements, the notch-and-reference li display, which eliminates parallax err and by automatic centering of pulses the display.

Better control of testing is effected the simple elimination of delay in o taining test results when compared the time lag of a calorimeter, which cludes calculations, photographs, grap and charts.

An operator measuring pulse pow for the calibration of diodes, for examp is able to constantly monitor his pow level with the prime measuring dev instead of substituting another diode other device for monitoring his level the testing progresses.

Basically, the PCS-1 unit measures pe pulse power by comparing the signal a plitude to that of an internally generat precisely measured, one milliwatt RF s nal. Reliance on factory precalibration eliminated by calibrating a Bolome with a bridge controlled on an absol basis by the use of precision standard sistors and a standard cell.

Laboratory tests indicate that measu ments made using the PCS-1 Pulse Pow Calibrator correlate with other peak po er measuring devices. Allowing for pected errors, the PCS-1 unit has a pr en maximum error of 13% (R.M.S. ror 6.9% or 0.29 db), as compared to

(*Continued on page 54*)

Whatever your spectrum

of uses for fabricated plastic parts, DIELECTRIC PRODUCTS can work effectively with you in developing

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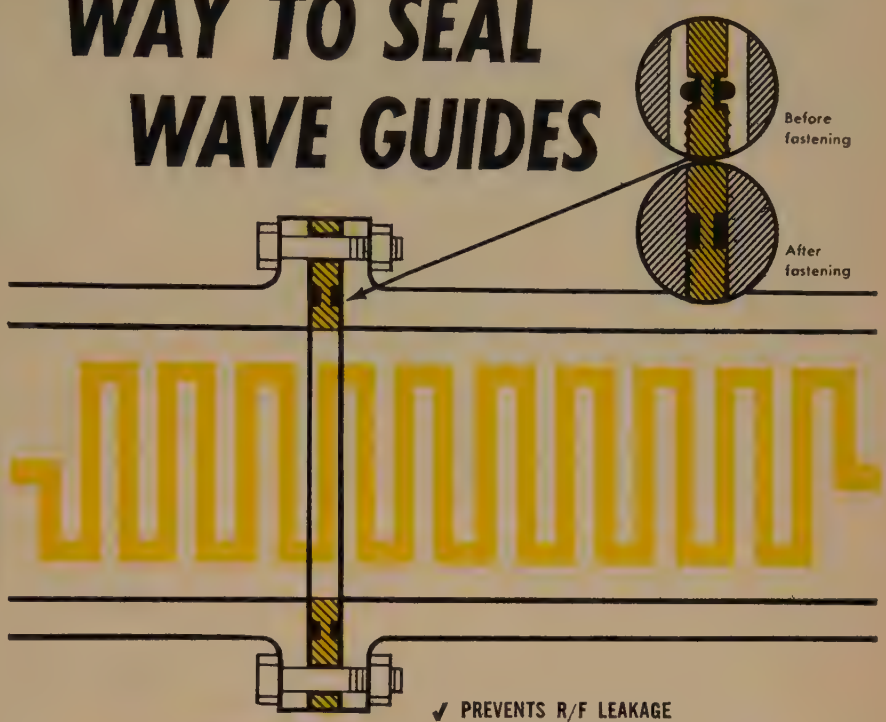
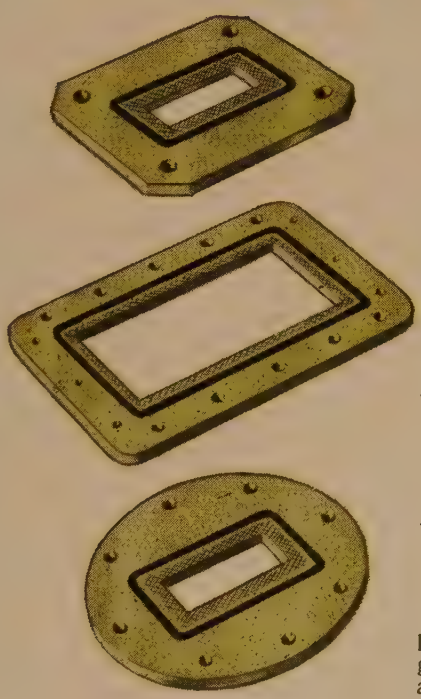
NOW THERE IS A BETTER WAY TO SEAL WAVE GUIDES





✓ **PREVENTS R/F LEAKAGE**
Metal-to-metal contact with "engraved fingers" on inside surfaces assures electrical continuity.

✓ **PROVIDES NO-LEAKAGE SEALING**
Controlled confinement of seal gland assures safe, sure, positive sealing — **exceeds** top hermetic specs!

✓ **ELMINATES ARCING AND/OR BURNING**
Designed to exacting requirements for proper mating of flanges as specified.

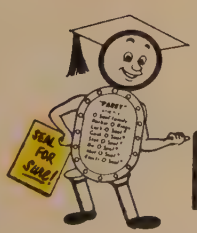
✓ **CAN BE RE-USED**
Seal is never "squeezed" beyond elastic limits, "memory" is constant, before, during and after fastening.

✓ **ECONOMICAL**
Eliminates cleaning or resurfacing flanges, no intricate machining required to accommodate the seal, and they're resuseable with just normal care.

✓ **STANDARDS FOR W/R SERIES**
Electr-O-Seals are available as standards to WR series Wave Guide flanges, assuring adequate supply and economy.

In addition to the standard WR series wave guide flange seals, Parker Seal Company also makes special seals to meet almost any specification or configuration. A nation wide group of field engineers are available to aid in expediting your requirements.

For more complete information send for catalog 5801.



Parker SEAL COMPANY
Culver City, California and Cleveland, Ohio
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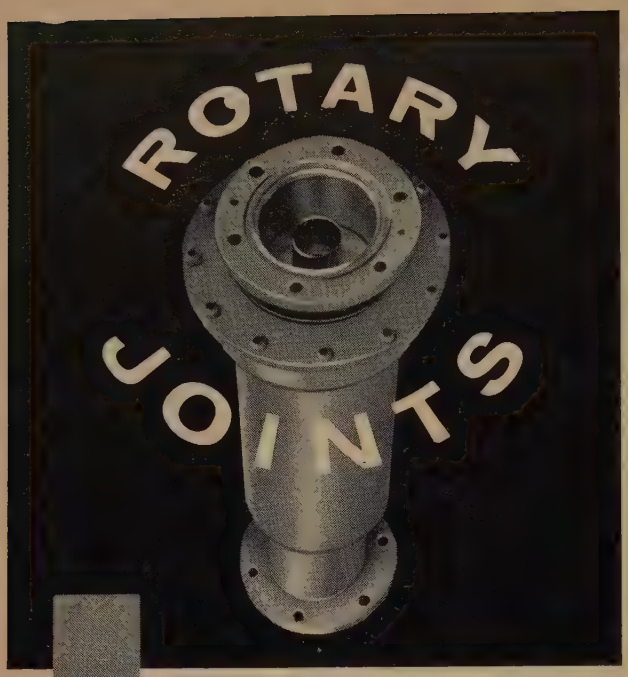

Diamond can offer the solution to your rotary joint problems — waveguide or coaxial . . . high power . . . inline . . . broadband . . . multi-channel — whatever they may be.

WAVEGUIDE IN-LINE ROTARY JOINTS

DIC NO.	W.G. SIZE	FREQUENCY KMC/S	VSWR (Max)	INSERTION LOSS (Max)	"WOW" (Max)	POWER HANDLING Peak	Average
445*	3 × 1½	2.6–3.95	1.5 : 1	0.1 db	.05 db	370 KW	3 KW
545*	2 × 1	3.95–5.85	1.5 : 1	0.1 db	.05 db	160 KW	2 KW
645*	1½ × ¾	5.85–8.2	1.5 : 1	0.1 db	.05 db	73 KW	1 KW
845*	1 × ½	8.2–12.4	1.5 : 1	0.1 db	.05 db	37 KW	1 KW
945*	.702 × .391	12.4–18.0	1.5 : 1	0.1 db	.05 db	16 KW	1 KW
1045*	½ × ¼	18.0–26.5	1.5 : 1	0.1 db	.05 db	8 KW	½ KW
1145*	.360 × .220	26.5–40.0	1.5 : 1	0.1 db	.05 db	3 KW	½ KW

* Patents applied for.

SINGLE CHANNEL COAXIAL ROTARY JOINTS

DIC NO.	LINE SIZE	FREQUENCY MC/S	VSWR (Max)	INSERTION LOSS	"WOW" (Max)
2045	6⅛	100–140	1.15 : 1.0	Negligible	0.5 db
2046	6⅛ (75 ohm)	400–700	1.2 : 1.0	Negligible	.05 db
2047	3⅛	200–400	1.2 : 1.0	Negligible	.05 db
2048	3⅛	400–600	1.1 : 1.0	Negligible	.05 db
2049	⅞	400–450	1.1 : 1.0	Negligible	.05 db
2049-2	⅞ (46.5 ohm)	2170–2320	1.15 : 1.0	Negligible	.05 db
2049-3	Type N	200–300	1.5 : 1.0	Negligible	.05 db
2050	1⅝	2100–2400	1.15 : 1.0	Negligible	.05 db
2400-1	⅜	4–15 kmc /s	1.8 : 1.0	Negligible	.05 db

DUAL CHANNEL COAXIAL ROTARY JOINTS

DIC NO.	CHANNEL	LINE SIZE	FREQUENCY MC/S	VSWR (Max)	INSERTION LOSS	"WOW" (Max)
2246	Main Auxiliary	6⅛ 3⅛	380–440 380–440	1.15 : 1.0 1.2 : 1.0	Negligible Negligible	.05 db .05 db
2247	Main Auxiliary	6⅛ Type N	415–455 I.F.F.	1.15 : 1.0 1.2 : 1.0	Negligible Negligible	.05 db .05 db
2248	Main Auxiliary	3⅛ 3⅛	785–815 785–815	1.1 : 1.0 1.15 : 1.0	Negligible Negligible	.05 db .05 db
2249-1	Main Auxiliary	⅞ BNC	2170–2320 30	1.1 : 1.0 1.1 : 1.0	Negligible Negligible	.05 db .05 db
2249-2	Main Auxiliary	Type N BNC	2150–2350 30	1.15 : 1.0 1.1 : 1.0	Negligible Negligible	.05 db .05 db
2250	Main Auxiliary	⅞ ⅞	215–260 215–260	1.1 : 1.0 1.25 : 1.0	Negligible Negligible	.05 db .05 db

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Salary: Up to $13,000

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NEW PRODUCTS

(*Continued from page 52*)

17% maximum error (R.M.S. error 9.3% or 0.39 db) for th calorimetric system. Actually, the feature of the Amplitud Reference line in the notched display is claimed to elimina at least 3% of the proven maximum error in the PCS-1A.

General Communication Company's present production un (PCS-1A) covers the frequency range 925 to 1225 megacycle The Company is planning to extend this patented method peak power measurement to cover the entire RF microwav spectrum in a series of similar units.

CIRCLE READER SERVICE CARD 114

LITERATURE . . .

D. S. KENNEDY ANTENNA FIELD SERVICE BULLETI

A new 4-page bulletin describing field service facilities f the antenna industry has just been released. Antenna installatio and maintenance through specialized field service departmen has become an important facet in today's huge, complex ele tronic equipments. The new free literature delineates the va ous types of field engineering service available, such as si selection, construction, supervision, antenna erection, maint nance and training.

The bulletin is published by D. S. Kennedy & Co., Cohass Mass. CIRCLE READER SERVICE CARD 125

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PRD MICROWAVE WAVEGUIDE CHART

PRD Adjustable Waveguide Chart indicates RETMA a ARMED SERVICES (JAN) standards for rectangular wav guides and flanges. One side of the chart indicates all RETM specifications for the entire frequency range of 960 MC/S 110 KMC/S. The other side shows JAN specifications for 1. to 90 KMC/S.

Information such as waveguide type, flange number, insi and outside dimensions, tolerances, wall thickness, type material, etc., are automatically shown in an indicator wind by a simple setting of the frequency dial.

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AVION acf

MICROWAVE COMPONENT ENGINEERS

these are important jobs with an important Name in microwaves!

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AVION, an established leader in the development and production of microwave components, is now expanding its microwave capability. This growth has created a need for Project Supervisors with sufficient technical leadership ability to direct a microwave group. Qualified engineers at other levels are also required.

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VARIAN ASSOCIATES

STANFORD INDUSTRIAL PARK — PALO ALTO, CALIFORNI

BOX SCORE

NAME: Varian Associates.

LOCATION: Stanford Industrial Park, Palo Alto, California.

PRODUCTS: Klystrons, traveling-wave tubes, backward wave oscillators, linear accelerators, microwave system components, NMR and EPR spectrometers, laboratory magnets, magnetometers, stalos, power amplifiers, graphic recorders, vacuum products, research and development services.

HIGHLIGHTS: World's largest dollar-volume producer of klystron tubes, continuing injection of new products, with heavy emphasis on research.

Anniversary Times Two

On November 2, 1958, two significant anniversaries were noted at Stanford Industrial Park, Palo Alto, when Varian Associates held an Open House. Ten thousand visitors helped the firm celebrate (1) Russell and Sigurd Varian's invention and development of the klystron tube in 1938, and (2) the founding of the Company in 1948.

Twenty years before, working in a basement laboratory at Stanford University, the Varian brothers succeeded wi their experiments when a klystron tube oscillated for th first time. This feat was a giant step forward in th microwave art, and inspired the founding of the Compan ten years later.

The activities of the Varian brothers during the wa years have been described in these pages.* After the wa the Varian brothers and four associates pooled assets o $22,000, and returned to California from their Easter wartime jobs to organize Varian Associates as a custom research organization. The new company's management trained in high level R & D, also had to learn abou business administration, finance and manufacturing, an then combine these elements into an efficiently operatin business.

A 1200 square-foot building was rented in San Carlo Calif. and Varian Associates was in business.

Growth

In 1949, H. Myrl Stearns, at that time the company executive vice president and general manager, and no president, landed a government contract and Varian Asso ciates was in the business of manufacturing tubes. (Toda the company is the world's largest manufacturer, in dolla

* Russell H. and Sigurd F. Varian, Inventors of the Klystron *the microwave journal,* Sept./Oct. 1958.

Varian's top management conference in President Myrl Stearns' office. Around the table, left to right: Sigurd Varian, vice chair man of the board; Ralph Kane, vice president, Instrument Division; Merle Zinser, vice president, Finance; Myrl Stearns; Emme Cameron, vice president and general manager; Howard Patterson, vice president, Tube Division and Russell Varian, board chairman

Artist's conception of Varian Associates' Palo Alto, California facilities, present and future. Existing buildings are shown left of the track which cuts through the 65 acre leasehold in Stanford Industrial Park. Work has begun on expansion "across the tracks" to the right, another step toward the ultimate one million square feet planned for Varian's Palo Alto plant.

volume, of klystron tubes.) Soon the San Carlos plant proved inadequate as new product lines were developed and a healthy backlog of orders built up. Varian was the first lessee of Stanford Industrial Park in Palo Alto, California. There Varian started with a 6-acre leasehold, later increased to 33-acres, on which facilities provide 300,000 square feet of space for research, development and manufacturing. This is still not enough, and building is almost continuously underway at Varian, under the direction of Emmet Cameron, Executive Vice President and General Manager. Acreage has now been increased to 65, and the "master plan" calls for a million square feet for the Palo Alto plant.

Products

Although founded as a research company, Varian Associates has succeeded both as a research and production firm. Dominant developers and manufacturers in the major areas of their operation — klystrons, spectrometers and electromagnets — Varian is also becoming a strong factor in other areas. These include traveling wave tubes, magnetometers, electron linear accelerators, backward wave oscillators, vacuum products, graphic recorders, components and accessories and electronic systems.

Tubes

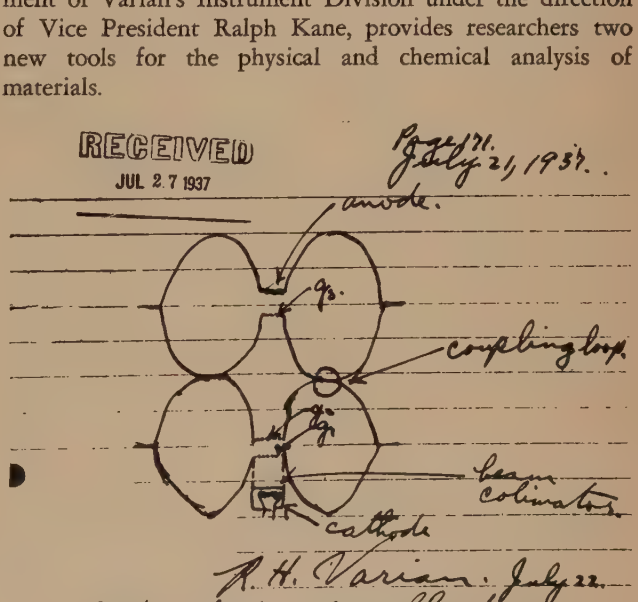
In a modern and efficient tube manufacturing building, Varian produces, under Howard Patterson, Vice President for Tubes, more than 100 different kinds of klystrons. Dr. Theodore Moreno, manager of Tube Research and Development, has in his department 35 additional klystron types in development. Varian also manufactures klystron parts, such as grids and flanges; accessories, such as power supplies and power meters; sub-systems incorporating klystrons such as pulsers and radar transmitters; and traveling wave tubes and backward wave oscillators. Their VA-125 is the largest sealed-off travelling wave tube ever built.

In addition to furnishing small tubes for military communications applications, Varian also produces large power tubes such as the VA-800C used in the NATO system. The firm has also manufactured complete systems, such as the high power transmitter designed and built for MIT's Lincoln Laboratories which is being used for investigation of long distance microwave communications using tropospheric scatter technique.

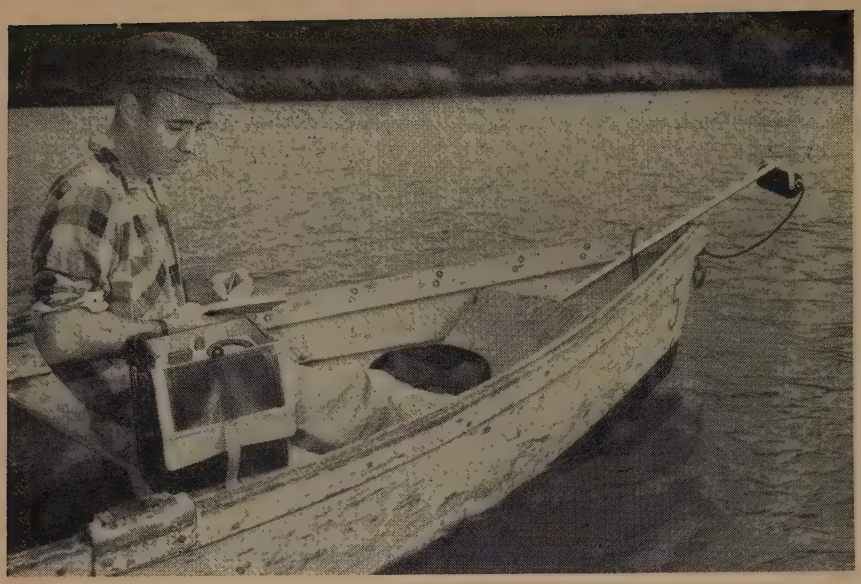
NMR - EPR

"Nuclear Magnetic Resonance," a new text by John D. Roberts, professor of organic chemistry at California Institute of Technology, calls NMR's discovery "one of the most important events in the past 50 years in the advancement of organic chemistry."

Intensive development of high resolution NMR equipment at Varian has resulted in the commercial reality of completely new techniques of NMR and EPR (electron paramagnetic resonance) spectroscopy. This accomplishment of Varian's Instrument Division under the direction of Vice President Ralph Kane, provides researchers two new tools for the physical and chemical analysis of materials.



A page from Russell Varian's notebook showing the diagram of the first Klystron Tube.



Varian's M-49, versatile one-man mi netometer, functions under rigoro conditions on foot or horseback o rugged terrain, in a boat over wa and from the air.

Varian's new 60 megacycle NMR spectrometer extends the scope and efficiency of this tool to a high degree. This instrument was exhibited last summer at the Brussels Fair by invitation of the U.S. State Department. Varian has become the world's largest producer of precision electromagnets, power supply for NMR-EPR spectrometers, and produces also graphic recorders including those used in its own analytical instruments.

Emphasizing the importance of this phase of the firm's operations, one hundred and twenty-five scientists from industrial and research groups throughout the U.S. and from six foreign countries attended Varian's second NMR-EPR Workshop held through a five-day session last October. Encouraged by the success of these workshops, conceived by Dr. Emery Rogers, Field Engineering Manager for Varian's Instrument Division, the Company has announced that they will be conducted on an annual basis with this year's sessions scheduled for October 19-23.

Magnetometers

Varian's Instrument Research and Development, headed by Dr. Martin Packard, has made notable contributions in measuring the earth's magnetic field with an ingenious magnetometer invented by Russell Varian, which employs the principle of proton free precession. Measurement of the earth's total magnetic field strength in the upper atmosphere is possible with a rocket magnetometer. Three magnetic observatories of the U.S. Air Force are equipped with these devices, and minified versions have been selected for future satellite and moon rocket flights. Still another type, the M-49, a portable magnetometer, has wide use among geologists and geophysicists in locating subsurface minerals.

Electron Linear Accelerators

These new instruments use Varian klystrons to provide energy needed to accelerate electrons to velocities approaching the speed of light. Varian built its first linear accelerator for DuPont for research in plastics. The University of California received the second for physics research. After testing in Varian's specially designed linear accelerator pit, two other models are scheduled for delivery in late 1959. Both these machines are to be used for the irradiation of foods, one by the U.S. Quartermaster Corps at Sharpe General Depot, the other by the Atomic Energy Commission of Denmark. These and other custo equipment are designed and manufactured by Varia Radiation Division, under the direction of Dr. Willia McBride.

Research

Aware of the danger of complacency, Varian pursu a policy of vigorous research. A new central resear department is headed by Edward Herold. The compa feels this new department is vital in a business involvi such a rapid rate of technical advance and obsolesce and frequent modification of product lines.

Vacuum Products

One of the revolutionary products to come out Varian's tube research laboratories is the VacIon,* tra name for a high vacuum pump. Feeling this new t will carry the high vacuum art into a new state of a vancement the management recently announced t formation of a new vacuum products division. Head by Dr. Louis Malter, the new division will be respon ble for the development, production and sale of VacI pumps, vacuum components and systems and vacu electronic devices.

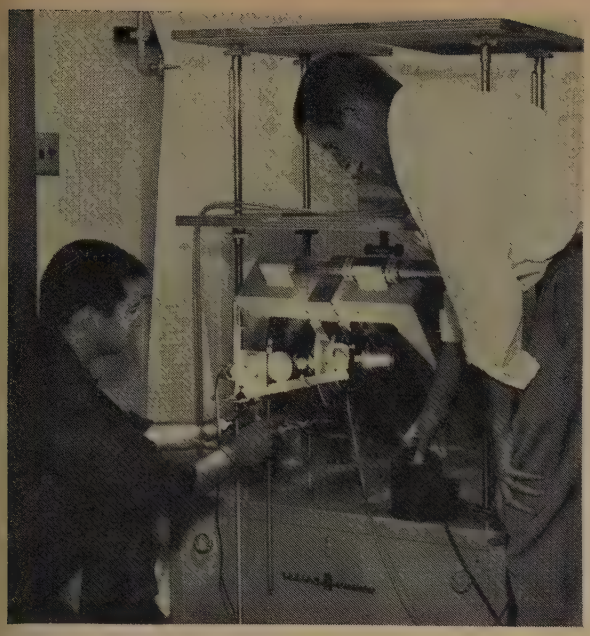
Advanced Training Program

This program was inaugurated by Varian in 195 a plan under which key personnel will be provided opportunity to extend their technical knowledge into n electronic developments. The first candidate, Dr. Rob L. Jepsen, spent a year working on microwave propert of ferrites at Harvard University. Dr. Arnold Bloom, s ond candidate, studied optical pumping under Dr. Kastl inventor of the technique, at the Ecole Normale Superie of the University of Paris. Dr. Harry Weaver, Varia third candidate, will spend a year at the Physikalisch Institute der Universitat Zurich doing research on nucl acoustical absorption and electron resonance.

Financial Growth

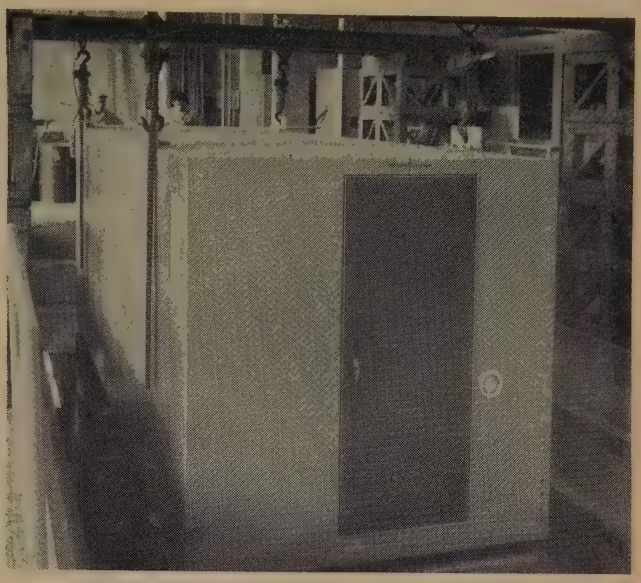
Varian's sales volume has kept pace with its physi growth. In its tenth year the company reported net ea ings close to $1¼ million on combined sales of the tu instrument and radiation divisions which totalled nea

* Trade Mark.



Thirteen ton "packaged" linear accelerator, only one of its kind in the world, is lifted from Varian Associates' barite-loaded concrete testing pit, preparatory to delivery to an undisclosed research laboratory.

Harry Weaver (left) and Bob Rempel, physicists in ERP (electron paramagnetic resonance) R & D, make last minute adjustments on their photosynthesis experiment for Varian's second annual NMR-EPR Workshop.



$20 millions. The nine month report for 1959 shows otal sales of $27,800,000, net income of $1,800,000 and otal assets of $24,700,000.

Financing the expansion of the company was directed by Financial Vice-President Merle Zinser.

Varian's first decade was one of steady growth and coming of age. Its first subsidiary, Varian Associates of Canada Ltd., was founded in 1955 and is engaged in the manufacture of klystron tubes. The eleventh year, ending July 7, 1959, finds the firm's wing-spread greatly increased with the addition of two new subsidiaries to the Varian Corporation. Acquisition of an 80% interest in the well-known Bomac Laboratories, Inc., Beverly, Massachusetts,** and formation of a research and development subsidiary, S-F-D Laboratories, Inc., located in New Jersey, is indicative of Varian's aim to build in the highly specialized electronics field through diversification of its products and addition of both manufacturing and R & D strength.

Bomac is one of the world's largest manufacturers of a line of switch tubes, which are essential components of pulsed radar systems. Its product line includes, also, magnetrons, silicon diodes and duplexers. Bomac sales for 1958 were about $10 millions, with earnings of approximately $450,000. Bomac operations continue under Harold Booth and Henry McCarthy, who have joined Varian Associates' board of directors. Booth was recently elected a Vice-President of Varian.

The newly-formed subsidiary, S-F-D Laboratories, is headed by Dr. Joseph A. Saloom, President, Dr. Joseph Feinstein, Executive Vice President and director of research, and Mr. Jerome Drexler, Vice-President and director of engineering. All three were formerly scientists with Bell Laboratories.

S-F-D will engage in research and development, with special emphasis on crossed field devices, including coaxial magnetron oscillators, and travelling wave magnetron amplifiers. Research is also planned in the fields of solid state and plasma amplifiers, beam-type parametric devices, and cyclotron resonance interaction.

Addition of Bomac and S-F-D has broadened Varian's product lines and strengthened the research program.

Varian also has a substantial export trade which it expects to increase, mainly in new product areas. Varian has established various working arrangements with foreign companies, and is studying the possibilities of broadening its licensing program and of establishing its own operations in Europe, either singly or as a joint company operation.

In looking at the company he helped to found, Russell Varian observed that in order to maintain and increase Varian's position in the electronics industry, the Company's management is committed to maintain a top-flight organization through research and development talent, production engineers, manufacturing, sales and supporting services.

** See "company profile — Bomac Laboratories, Inc." pp. 50-3, Nov./Dec. 1958, *the microwave journal.*

Subsequent to the preparation of the Varian Associates profile, Russell Varian died of a heart attack on July 28, 1959, while vacationing with his family in Alaska. We feel that the scientific world has suffered a great loss with the passing of Russ.

ENGINEERS AND PHYSICISTS R & D ON NEW MICROWAVE DEVICES

Microwave Associates, Inc. invites qualified engineers and physicists to discuss an unusual opportunity to perform R & D work on new microwave devices utilizing ionized media, ferrites and semiconductors. A broad background can be achieved in the interaction of electromagnetic energy with non-linear lossy dielectrics. Here is an opportunity to grasp the advantages of each medium, combine their properties, and develop new devices.

Excellent high power and low power facilities are available for complete study and test of these devices over a wide frequency spectrum — 400 to 70,000 MC.

You are invited to a confidential exploratory discussion of your future with us. Contact Dr. Lawrence Gould for suitable arrangements.

MICROWAVE ASSOCIATES, INC.

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NEW PRODUCTS

5 MEGAWATT S-BAND ISOLATOR BY MICROWAVE ASSOC.

A liquid-cooled, high power ferrite load isolator, Model # MA-154, has been developed for use in radar systems operating in the 2700-2900 Mc frequency range. The MA-154 features reliable operation at 5 megawatt peak and 4000 watts average power. High efficiency forward RF transmission properties are assured by an insertion loss of less than 0.4 db. Isolation is 10 db minimum. Overall dimensions are: length 12″, height 8″, and width 3 ½″ (measured from center line of waveguide). The MA-154 ratings apply over an ambient temperature range of O°C to 65°C. Bronze RG-48/U waveguide is used. Approximate weight is 50 pounds. Flange connections are UG-53/U input and UG-54A/U output. The isolator is rated for continuous use at 20 psig minimum at full rated power.

Modified MA-154 isolators used in tandem are available for use at peak power levels in excess of 5 megawatts peak and at 10 kw average. High power performance is insured by testing MA-154 isolators at full rated power conditions. MA-154 isolators are now in production.

Nine other high power isolators are listed in a new bulletin (59F) available from Microwave Associates, Burlington, Massachusetts.

CIRCLE READER SERVICE CARD 115

• • •

NEW DEVELOPMENTAL RCA TUBE FOR RADAR DISPLAY CAN PICK OUT TWO CLOSELY SPACED TARGETS

A new display storage tube, providing a high level of resolution never before achieved in a similar tube, has been developed by the RCA Electron Tube Division for use in radar and specialized television applications.

"High resolution," explained D. Y. Smith, Vice President and General Manager of the Division, "describes the ability of a tube to display a radar pattern with very sharp detail.

"This new tube, known as developmental type C-73959, has approximately twice the resolution capability of heretofore

(*Continued on page 62*)

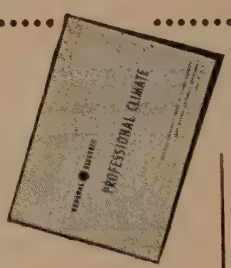
engineers

What kind of professional climate is essential to you as a creative man?

The "right" Professional Climate doesn't just happen. It has to be created — painstakingly, with careful planning, foresight and creative inspiration.

If you would like to know how General Electric's Advanced Electronics Center at Cornell University has built an ideal creative environment — and the many opportunities and rewards that await you as an engineer or scientist at the Center — please clip and return the coupon below for your free copy of the brochure entitled "Professional Climate."

GENERAL ELECTRIC



Mr. James R. Colgin, Div. 127-MI
Advanced Electronics Center at Cornell University
General Electric Company
Ithaca, New York

Please send me a free copy of the brochure "Professional Climate."

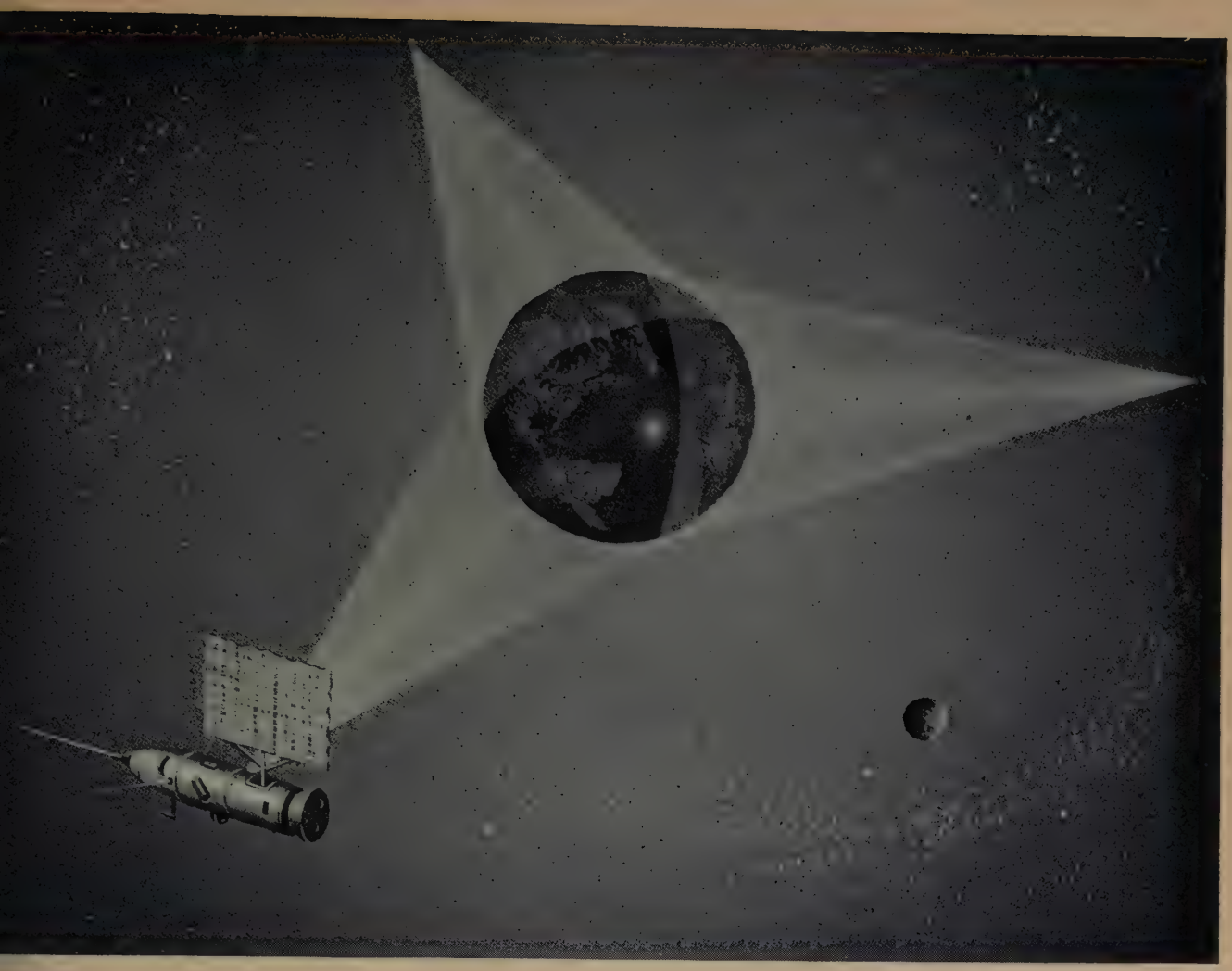
NAME

ADDRESS

CITY & STATE

DEGREE(S)

My field of interest is (please check) ☐ *Data handling* ☐ *Radar* ☐ *Human Engineering* ☐ *Infrared* ☐ *Electronic Systems* ☐ *Communications* ☐ *Vehicle Guidance* ☐ *Engineering Data & Publications* ☐ *Engineering Physics* ☐ *Servo Systems* ☐ *Advanced Circuit Design* ☐ *Countermeasures.*



THE FAR REACHES OF MAN'S KNOWLEDGE

Over the years ITT Laboratories has made significant contribution to advancing the state of the art in electronics. Today highly evolutionary progress is moving apace in such areas as broadband communications systems, low-noise parametric amplifiers, atomic clocks, inertial navigation systems, high density storage tubes, and space guidance, navigation and flight control. Major achievements are resulting in stored program digital computers and digital communications.

While engineers and scientists at ITT Labs meet the urgencies of today, they are simultaneously exploring the far reaches of man's knowledge, accepting small failures, making small successes, to unlock the doors to revolutionary achievements in electronics.

Communications, as essential to civilization as food and shelter, is an area of unlimited challenge which constantly occupies our efforts. To find more room within the radio spectrum for electronic communications — from direct current to the cosmic rays — is a major goal. Revolutionary ways to extend communications is another. We foresee early success with single satellite systems of the delayed-transponder type, and possibly passive reflector satellites. In only a few years ITT's "Earth Net" communication system may be a reality, providing global communications via three satellites in orbit. Within a generation, world-wide television may be a commonplace.

Positions of responsibility, challenge and reward are open to engineers with minimum B.S. degree and U.S. Citizenship. For information regarding specific positions, write G. T. Wall, Technical Placement Director.

ITT LABORATORIES

A Division of International Telephone and Telegraph Corporation

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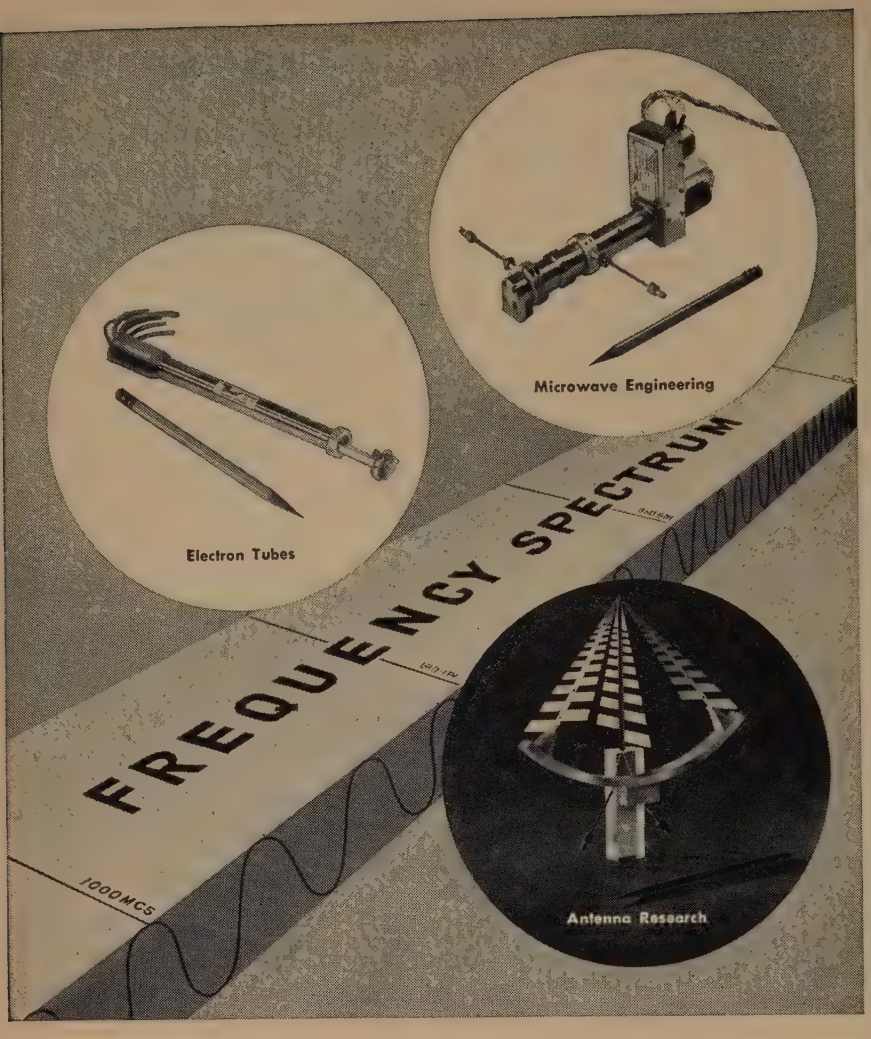

OPPORTUNITIES IN UHF AND MICROWAVE RESEARCH AND DEVELOPMENT

Never before has such high priority been given to microwave research and development . . . never before have the opportunities been so great in this field for the qualified engineer and scientist.

The Research Center of the Bendix Aviation Corporation—The RESEARCH LABORATORIES DIVISION—is expanding its programs in the UHF and microwave field to create interesting and challenging positions for qualified personnel.

Technical openings are now available in the following fields:

ANTENNA RESEARCH in electronic scanning, log periodic antennas, microwave optics.

MICROWAVE ENGINEERING—in ferrite devices, electronically controlled phase shifters, parametric amplifiers.

ELECTRON TUBE research in BWO and TWT from 1,000 to 150,000 mcs.

Investigate these opportunities *now*, where your technical competence and potentialities will receive full recognition in "Building Your Future with Bendix".

If interested, please write or wire Fred A. Barry, Research Laboratories Division, Bendix Aviation Corporation, P.O. Box 5115, Detroit 35, Michigan.

Research Laboratories Division
SOUTHFIELD, MICHIGAN

Bendix
AVIATION CORPORATION

available display storage tubes," he sai

"When used as a radar indicator, t tube is capable of distinguishing betwe two closely spaced targets. Previous d play storage tubes would often make tw such targets as one object.

"The new tube is capable of resolvi more than 800 TV lines per displ diameter of 3.8 inches when operated a display of picture brightness of appro mately 100 foot-lamberts. This brightne is adequate for viewing in a well light room without a light shield.

"The tube can be utilized in electron equipment for long-range radar displ and airport surveillance radar. In add tion, it can be employed for data transm sion including half-tones and for speci ized television applications involving na row bandwidth transmission over te phone lines."

CIRCLE READER SERVICE CARD 1

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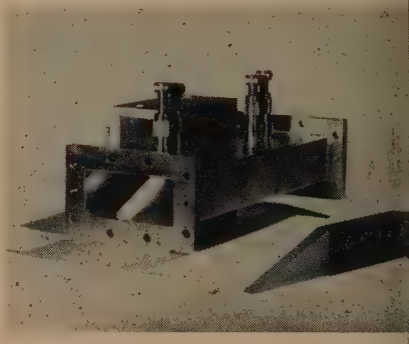
FERROXCUBE FOR MICROWAVT

Ferroxcube Corporation of Ameri Saugerties, New York, announces a bro line of ferroxcube material, developed e pressly for ultra-high and super-high fr quency applications in the microwa field.



Designated as Ferroxcube 5, the ne material is currently being offered in variety of shapes and sizes for use rotation, resonance and field displaceme isolators and other uni-directional d vices operating in S, X, K, Q or V banc Complete technical information a availability of sample kits furnished request.

CIRCLE READER SERVICE CARD 1

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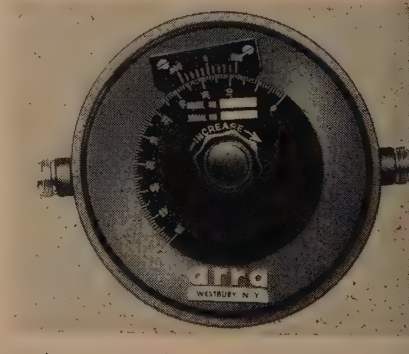
VAMP



Antenna and Radome Research As ciates, Westbury, N.Y. announces an dition to its standard line of variable tenuators — a new type of variable

(*Continued on page 64*)

TEST
INSTRUMENTS
for
LABORATORY/PRODUCTION
FIELD TESTING

measure microwave power directly, quickly, accurately

TRANSISTORIZED POWER BRIDGE

The AIL Type 50 R-F Power Bridge applies the most advanced transistor circuitry techniques to power measurements in the 10-40,000 MC range. Full scale ranges of 1.0 and 10 milliwatts and plus and minus 10dbm are provided. Accuracy within 0.5 db.

Compact—battery operated—weighs less than 4 pounds—hand held—ideal for field applications.

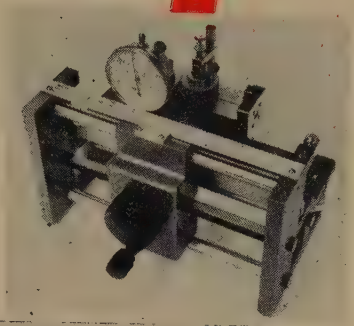
Each Type 50 is carefully checked and tested under the rigid AIL quality control system assuring highest reliability for a variety of applications in:

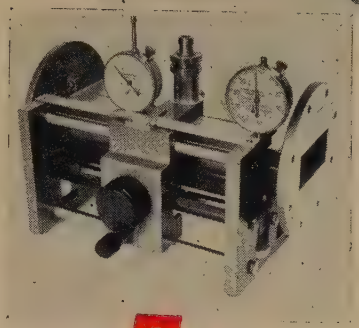
Radar • Communications
Navigation • Telemetering
Television • Transmission lines
Microwave links • R-F leakage

Price *$199*

Airborne Instruments Laboratory
1345 NEW YORK AVENUE
HUNTINGTON STATION, L.I., N.Y.
A Division of Cutler-Hammer, Inc.

CIRCLE READER SERVICE CARD 39





SAGE

Illustrated above* is the versatility of the SAGE-601 Slotted Line Carriage. At one extreme it is shown with the S-Band SAGE-606 Slotted Section, the SAGE-615 Automatic Phase Indicator and the SAGE-602 Broad Band Adjustable Probe. At the other extreme it is shown with the Ka-Band SAGE-613 Slotted Section and the SAGE-605 Broad Band Probe.

All slotted lines have tapered slots for minimum residual VSWR. The Automatic Phase Indicator operates with all slotted lines from 2,600 to 40,000 Mc.

PICTURED ABOVE

SAGE-601 Slotted Line Carriage	$225.00
SAGE-606 S-Band Slotted Section	210.00
SAGE-613 Ka-Band Slotted Section	140.00
SAGE-602 Broad Band Probe	35.00
SAGE-605 Broad Band Probe	125.00
SAGE-615 Automatic Phase Indicator	100.00

*Drastic economy measures have been taken this month to enable Sage to move into new and larger quarters, ergo the absence of the Sage half dollar.

CIRCLE READER SERVICE CARD 45

SAGE laboratories, inc.
150 LINDEN STREET WELLESLEY 81, MASS.

Expanding the Frontiers of Space Technology in

SYSTEMS ANALYSIS

■ Lockheed Missiles and Space Division has complete capability in more than 40 areas of science and technology. As systems manager for such major projects as the DISCOVERER Satellite; Navy POLARIS FBM; Air Force Q-5 and X-7 and Army KINGFISHER, the Division is extensively engaged in improving the art of systems analysis and integration.

ENGINEERS AND SCIENTISTS

The Division's programs reach far into the future and deal with unknown and stimulating environments. It is a rewarding future with a company that has a continual record of progress and achievement. If you are experienced in one or more of the following, we invite your inquiry: classical dynamics, vector analysis and matrix operations, with the ability to establish and analyze weapon systems performance; inertial guidance systems; dynamics of missiles systems; or long range ballistic fire control systems. Ability to prepare and edit technical reports documenting results of systems analysis studies is a requirement.

Write: Research and Development Staff, Dept. I-27, 962 W. El Camino Real, Sunnyvale, California. U.S. citizenship required.

Lockheed

MISSILES AND SPACE DIVISION

Systems Manager for the Navy POLARIS FBM; DISCOVERER, SENTRY and MIDAS; Army KINGFISHER; Air Force Q-5 and X-7

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tenuator called the VAMP (Variable Microwave Power). These units feature quick change in attenuation because the total attenuation range is traversed in less than 180 degrees of revolution of the drive shaft.

The VAMP is further characterized as follows: Power capacity: 10 watts avg.; Attenuation range: 0-30 db; Backlash: None; Weight: Approximately 2½ lbs.; Size: 5" diameter x 1" high excluding connectors and dial face-max. for S-band — to — 3" diameter x 1" high excluding connectors and dial face — for X-band; Frequency range: 2-4 KMC, 4-7 KMC, and 7-11 KMC.

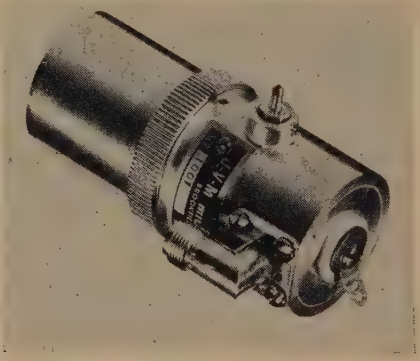
The VAMP provides accurate resettability, meets MIL specs., and is suitable for airborne and missile applications. Technical information, outline drawings, and price and delivery information may be obtained from the manufacturer.

CIRCLE READER SERVICE CARD 118

• • •

NEW TRIODE CAVITY LINE PERMITS 30 DAY OFF-THE-SHELF DELIVERY

Offered as the first complete, standardized line of triode cavity components, JVM's new MERCURY '10' series features component availability, design selectivity, and uniform performance — custom assembled to specification at stock unit economy.



Series '10' cavities are engineered for restricted 10% tuning range. Small size, minimum weight-frequency stability and temperature compensation are also offered. Cavities are designed to meet environmental requirements of MIL-E-5272 and military construction requirements of MIL-E-5400.

Available for a variety of different tube-types, the MERCURY '10' series is designed for maximum power and/or voltage ratings of tubes. Cavity designs are available in a frequency range from 255 mc up to high frequency limits of existing planar triodes. A total of 720 different cavities are available in the line.

CIRCLE READER SERVICE CARD 119

TO OUR READERS

In many cases "the microwave journal" is being sent to your home address in order to lessen the burden on company mailroom facilities.

VER

SCAL

212 L EXPEDITE

OPENINGS N
ON PROGRAM 21
(Air Weapons Control Sy

The Heavy Military Electronics Department of G.E. has been awarded responsibilities for Systems Management, Systems Integration and Systems Engineering of AWCS 212L—a Universal Electronic Control System to meet the vast problem of Air Defense outside the continental United States.

Designed for both fixed and mobile applications, 212L will be an ultra flexible system. It can be used to defend a single airfield or—by linking control sites together—provide air control for an area the size of Alaska. By integrating capabilities of several countries, it can operate as the air defense system for an entire continent.

In addition to its prime function of Systems Management, HMED will design, develop and produce the Data Processing and Display Subsystem, which is the heart of 212L.

Also Openings on Diversity of Other Far-ranging Programs in:

Fixed & Mobile Radar; Shipborne Radar; Shipborne Search Sonar, AN/SQS-26 (a new responsibility), Underwater Detection Systems; Missile Guidance; Far Flung Communications.

ENGINEERS • SCIENTISTS

An Unprecedented Opportunity
Enter the Field of

LARGE SYSTEMS

with GENERAL ELECTRIC

Yesterday's systems must today be considered only "subsystems" to be integrated into a larger entity. The growing demand of the defense establishment for super-systems offers challenges of unprecedented scope to the engineering profession.

Now HMED offers able engineers an opportunity to get full exposure to this field of the future – to learn, grow and develop their capacities for systems thinking, by working with men who have been in-at-the-beginning of major systems design and integration programs.

Facts and Figures Behind Growth Opportunities Here:

At HMED you are joining an organization providing professional people with an outstanding combination of CAREER STABILITY plus INDIVIDUAL PROGRESS. In the last few years this G. E. department has *doubled* its dollar business volume; *tripled* its engineering laboratory and office space; *quadrupled* the number of its supervisors and managers, from 26 to 101, with 90% promoted from within; *quintupled* its professional engineering staff.

CUT COUPON ON DOTTED LINE

☐ **COMMUNICATIONS ENGINEERS** – To work with Propagation consultant in frequency choice versus sight configuration, and design of optimum communication and sight configuration. (BS in EE and 3 years' experience necessary)

☐ **RADAR SYSTEMS ENGINEERS**—To integrate varied data acquisition equipment into complex electronic control systems. (Advanced EE degree preferred with minimum 3 years' experience)

☐ **TELECOMMUNICATIONS ENGINEERS** – To design and develop advanced communications subsystems of ground electronic control system complex. (EE degree and 5 years' experience)

☐ **PROPAGATION CONSULTANTS**—To assist in the design, development and management of radar and communications subsystems as applicable to an air defense system. (Advanced degree in EE or Physics with 5 years' experience)

☐ **RADAR RECEIVER & VIDEO PROCESSING ENGINEERS** – To establish receiver design criteria for optimum system performance in varied environments, particularly ECM. (Advanced EE degree or equivalent and minimum 5 years' experience)

☐ **ECM SPECIALISTS** – To provide threat models and consultation to design and management engineers. (Advanced degree in EE and 3-5 years' experience)

☐ **ANTENNA AND MICROWAVE ENGINEERS** – To establish antenna design and sighting philosophies for optimised detection system performance. (Advanced EE degree and 5 years' experience)

☐ **RADAR DESIGN ENGINEERS** – To work on advanced designs and development of receivers utilizing parametric amplifiers. (BSEE and 2-4 years' experience)

☐ **PERSONNEL SELECTION AND TRAINING SPECIALISTS** – To prepare job evaluations, manning structures for complex military systems, and forecast training aid needs. (PhD or EdD required)

☐ **EQUIPMENT EVALUATION SPECIALISTS**—To solve man-machine problems, evaluate alternative components, displays, or techniques and devise simulators. (PhD in Experimental Psychology)

☐ **CABLING ENGINEERS** – To resolve varied problems in grounding and associated shielding problems of complex electronics equipments. (EE degree with minimum 2 years' experience)

☐ **LOGIC DESIGNERS** – To organize and perform logic designs of a high speed digital computer. (Degree in EE, Math or Physics with minimum 4 years' experience)

☐ **CIRCUIT DESIGN ENGINEERS (DISPLAY)** – To analyze equipment and circuit design requirements in data utilization and display subsystems. (Electrical Engineering degree with minimum 5 years' experience required)

☐ **SYSTEMS ANALYSTS** – To conduct system analysis programs and feasibility studies which lead to the conception and development of new systems, subsystems, and equipments of advanced design and function. (Advanced degree in EE, Math or Physics preferred with 3 years' previous experience)

☐ **TECHNICAL WRITERS** – To organize, write and publish progress and planning reports. (Engineering degree preferred with previous technical writing and editing experience in advanced electronics)

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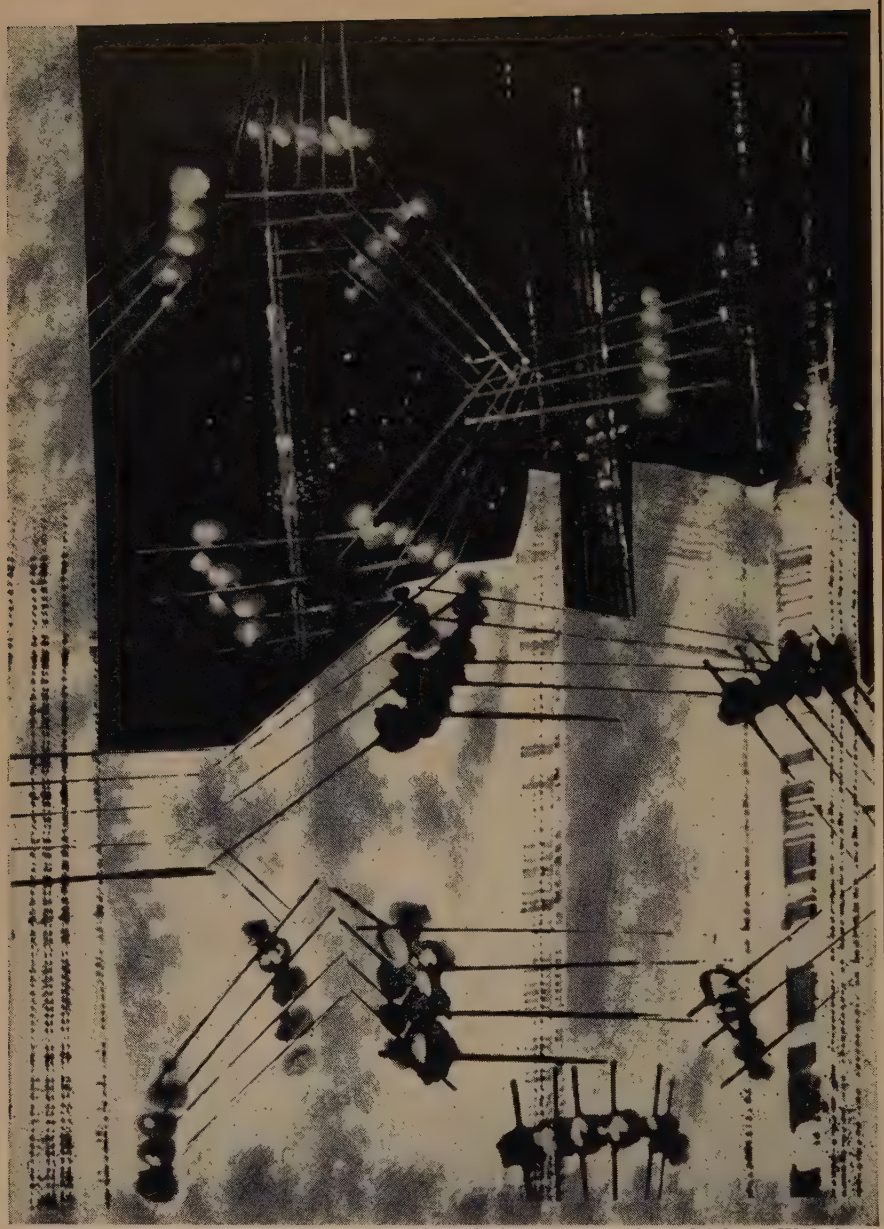

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A VIEW OF THE ELECTRONICS INDUSTRY IN SCOTLAND

A. L. WHITWELL
JAMES SCOTT Ltd.; GLASGOW, SCOTLAND

Early in 1956, James Scott Ltd., an established firm of lectrical installation engineers, decided to enter the elec-ronics field and my responsibility was the formation of a evelopment and manufacturing division, specializing in lectronics. This marked a major change in interest and olicy on the part of the firm and is typical of a situation vhich is becoming increasingly common in Scotland to-ay. Some of the problems and situations, both geo-raphical and historical, which we have encountered in he course of developing our new division may be of in-erest to readers of these pages.

Scottish industry is still largely centered in the western egions, in and around Glasgow, although there are quite arge pockets over to the east and north east, but the most utstanding fact about this industry is that on the whole it s concerned with the raw materials, processes and products f heavy engineering, coal, oil, structural steel and ship-uilding. Only in post war years has there been any narked spread of manufacturing interest to include light ngineering products, and several hundred new plants ave been established on industrial sites.

There are a number of good, sound, economic reasons or choosing this area, especially in the long-term view, and a number of U.S. firms have set up plants and by doing so have contributed towards the stabilization of the Scottish economy.

The major advantages are, first, that because of the preponderance of heavy engineering there is always a surplus of female labour; second, the heavy engineering industry is contracting in certain sectors, for example certain coal-fields are being worked out, and so there tends also to be a good pool of male labour, although generally in the "unskilled" categories; third, there is ample space for development and good communications to sea ports and the other U.K. areas; and finally, the local and national authorities have adopted a policy aimed at speeding up the expansion and diversification of Scottish industry and offer many inducements in the way of tax concessions and capital assistance in building, to help this aim.

There are, also, some disadvantages, the seriousness of which depends to a great extent on the particular industry or products concerned. For example, there is only a limited local production of steel strip, so this material has to be freighted over a distance of about 400 miles. In another few years, however, new local rolling mills

(*Please turn to next page*)

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will be in operation and this disadvantage will be eliminated.

A number of manufacturers in the electronics and allied fields are now established here and their products include cash registers, tabulating machines, electronic computers, precision potentiometers, radar systems and components, electronic machine tool controls, and so on. Their numbers are still far too few by any standard. It has been estimated that on a straight population basis, the people employed in the electronics industry in Scotland cannot exceed 3,000, by comparison with upwards of 250,000 in the whole of the U.K. It will be appreciated that if, from the Scottish total, we extract figures for those employed directly on microwaves, in one way or another, the number would be extremely small. In the U.K. as a whole, there are only a few firms, and most of these are comparatively small, which set out to make only microwave components or systems. The greater part of British efforts and interest in microwaves is shared between various Government research departments and major industrial concerns — internationally known companies with a wide range of interests — so that it is very difficult to get factual information about the financial and technical resources involved in the British microwave industry. All that can be said is that it is small by American standards, but supported by an able and enthusiastic nucleous of engineering effort, as shown to some extent by publications in the technical press, although there is, of course, a considerable hidden effort which does not find expression in print because of security restrictions.

This is the background against which the development of our new division has to be viewed. In deciding on a general policy, we had to keep in mind the absence of a local pool of skilled labour and the need to accept the fact that most of our labour would have to be trained and experienced engineers of graduate status would be hard to come by. We decided to allow the business to develop naturally, by always equating the capital involved against the order position, and are satisfied that this rather cautious approach has paid many dividends which are not, perhaps, immediately obvious.

In the first place, it has created a pool of skilled labour, both in the laboratories and the workshops. Expansion has been at the rate of approximately 30% each year and this, we feel, is about the maximum growth rate that can be accepted without causing too many dislocations in the organization. Staff have had time to master their jobs and have always been over, rather than under employed, so there is a real sense of urgency in getting on with the job. Promotion avenues tend to increase as time goes on, providing incentives to staff at all levels.

During the first two years, we obtained production an development work on industrial and defence sub-contrac and this gave us time to think over our policy for futu products of our own design. The fact that a number of o engineers had radar development experience, combine with a plant set up with good machining facilities, led almost inevitably to decide to look specifically for electr mechanical items to manufacture.

We have recently marketed our first commercial rang of instruments, chiefly special-purpose, microwave an video spectrum analyzers, and our engineers are strivin to complete the engineering and development of a numb of new models. With the present tendency to create mo favourable conditions for international trade, we are pa ing close attention to the varying design standards whic apply in different countries and are making a special effo to design all new products for an international marke Fortunately, the considerable standardization in the com ponent and hardware fields achieved by NATO has made easier for the manufacturer to buy components rated to in ternationally recognized standards.

Within the confines of our corporate outlook as a com pany, we are in favour of a much extended internation trading level. In our own field we are confident of ou ability to compete for instruments and system produc where the available markets will only support relative small-scale production and where the skilled labour a high proportion of total costs. On the other hand, w would like to be able to buy components and capital goo of the best available type and our choice would obvious be much greater in a "free" market than in conditions strong protective tariffs and quota restrictions.

In October, 1958, I travelled, in company with a senio colleague, to North America. Our purpose was to loo around to see what prospects there were for marketing ou products and generally determine what we would have t do to win a small niche for ourselves in your market. T say that we learned a lot is putting it mildly. In the cours of eight days in Toronto, Canada, at the IRE Convention and ten days in the areas of New York, Boston and Ch cago, we sent reports to the tune of 20,000 words air mai back to base, and visited many firms in these areas. Abov all, we will never forget the unfailing courtesy and goo humour of those who had the job of meeting us to discus our business interests, and we can only say that an American visitor to our island can be sure of a welcom in Glasgow.

As a final postscript, I would mention that we foun the niche we were seeking and will be visiting again th year and, I hope, for many years to come.

Arthur L. Whitwell was born in Bristol, England, in 1922. His formal education was directed towards a career in a countancy until the advent of World War II. After six years of radar service in the Royal Navy, he was convinced that a permane change to electronics engineering would offer opportunities for a career which would be satisfying in every respect.

The need to follow the steps of a formal education in engineering and, at the same time, gain practical experience ar meet family responsibilities could only be met by working long hours with little time for leisure and Mr. Whitwell pays fu tribute to the patience and understanding of his wife, Betty, whose encouragement was a vital factor in achieving success. H efforts were rewarded, however, first by the award of a B.Sc. degree from London University, and then by corporate membersh of the Institution of Electrical Engineers.

From 1947 to 1953, he was on the research staff of the Boulton Paul Aircraft Company, including four years as head electronics development department, and then followed a period of three years as chief of electronics, R. and D., with scienti instrument makers, Barr & Stroud Ltd. His work in these positions covered many aspects of military electronics, including flig instrumentation, analogue computors, control systems and radar systems.

In 1956, he joined his present company, James Scott of Glasgow, as manager of a new electronics division specializing work of a development nature, but with manufacturing facilities.

The Landing of the Puritans

On the banks of Gitchie Goomie,
Lake the white men call Atlantic
Heap big redskins going frantic,
*Radar got no Bomac tubes!**

See the Pilgrims land on rock there!
See them cross the sky blue water!
Redskins know they hadn't oughter,
But radar got no Bomac tubes!

Beat the drum, call heap big powow,
Call the braves from heap big teepee,
Get um chief to put on toupee —
Radar got no Bomac tubes!

Fixum Cavity, Bald Eagle!
Get um faulty Klystron going!
Heap big white men come a-rowin
And radar got no Bomac tubes!

Storm Cloud, get those fingers flying!
Mend with rawhide, patch with sticks
Too late now to get um "fix" . . .
Radar got no Bomac tubes!

Redskin radar rests in ashes,
White men use um wood for fire, now.
Price of real estate is higher now . . .
Radar had no Bomac tubes!

On the banks of Gitchie Goomie
Different people now are living,
Every year they give Thanksgiving
Radar had no Bomac tubes!

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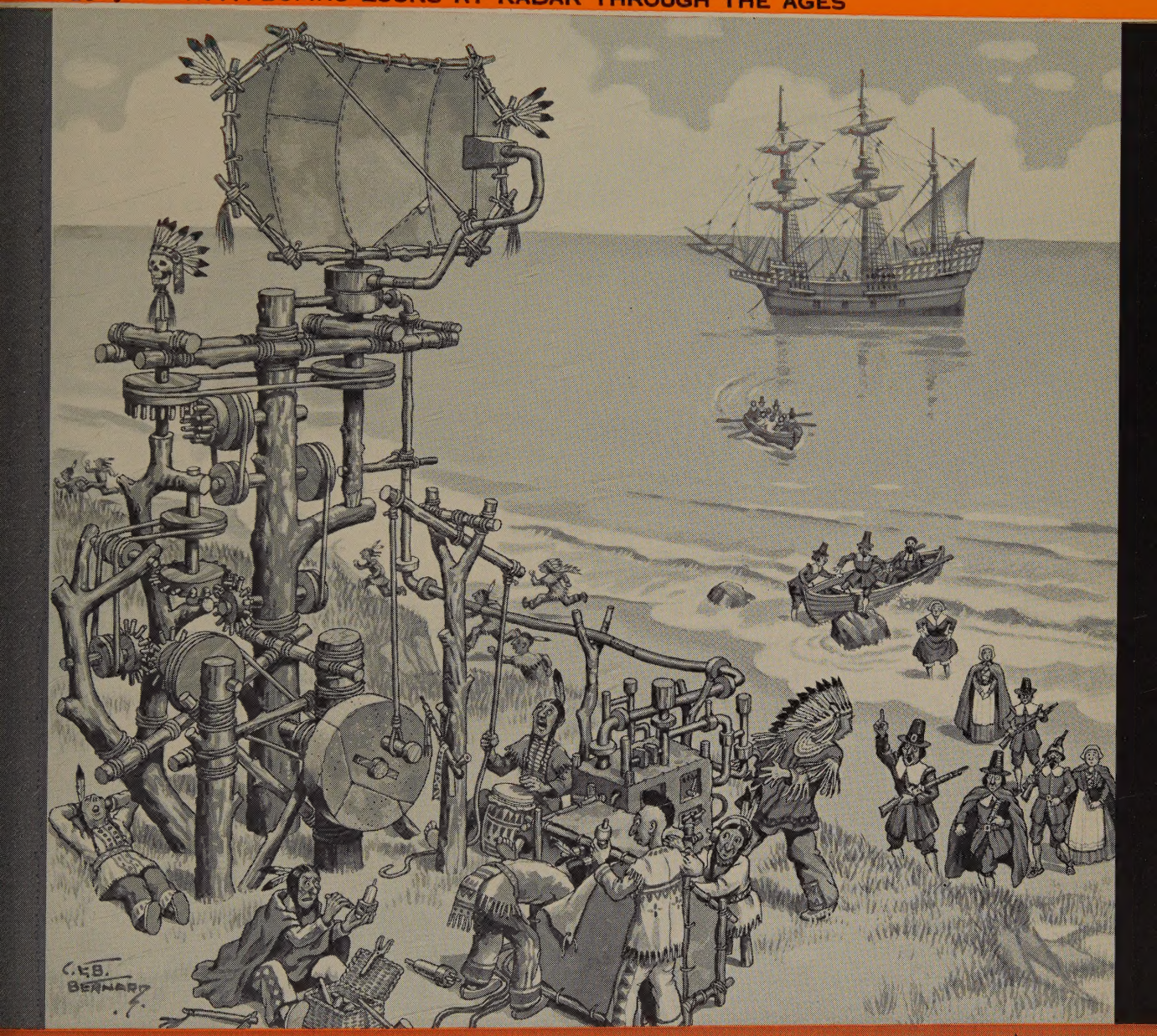

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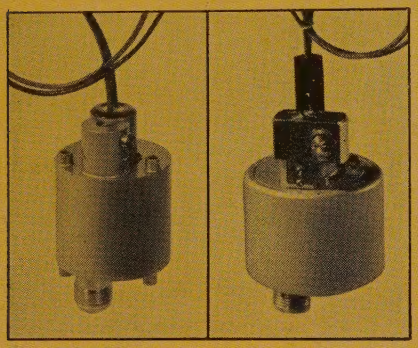
Creative Microwave Technology

Published by MICROWAVE AND POWER TUBE DIVISION, RAYTHEON COMPANY, WALTHAM 54, MASS., Vol. 1, No. 5

NEW RAYTHEON MICROWAVE TUBE DEVELOPMENTS

Miniature pulsed magnetrons for missile beacon applications are ruggedly constructed with integral magnets. The RK-7461 is tunable from 9,300 to 9,500 mc and has minimum peak power output of 60 watts. It is 1¼" in diameter and 2½" long, and weighs only 6 ounces.



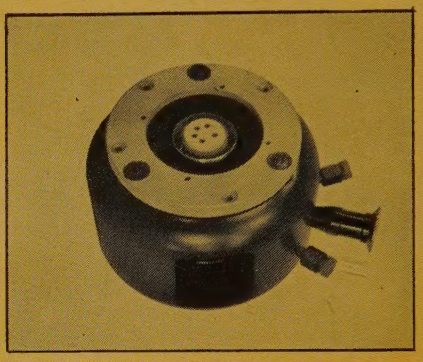
RK-7461 QK-735

The QK-735 is tunable from 5,400 to 5,900 mc with minimum peak power output of 400 watts. 1½" in diameter and 3¼" long, it weighs 8 ounces.

CIRCLE 40
Reader Service Card

* * *

Designed for electronic countermeasures and FM/CW operations, the QK-625 BWO provides a minimum CW power output of 180 watts and a nominal CW power output of 250 to 350 watts over the 2,500 to 3,000 mc band. The tube is voltage tunable over the entire range with tuning sensitivity of approximately 0.4 mc/volt. Liquid-cooled, the QK-625 BWO is equipped with an integral



permanent magnet, and can be mounted in any position.

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* * *

Small-signal gain of up to 35 db in microwave relay links is achieved by means of a new compact traveling wave tube amplifier -- the QK-542. This permanent-magnet focused CW tube has nominal saturated power output of 5 watts over 5,900 to 7,400 mc. An integral UG 344/U waveguide-type flange is supplied as standard. With an optional coaxial output coupler the QK-542 covers 4,000 to 8,000 mc.

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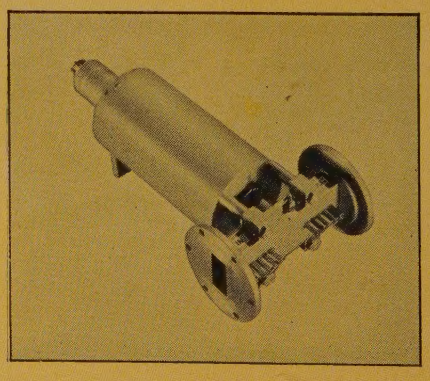

Ideal for linear accelerators and high-power radar systems. The QK-783 and QK-622 Amplitrons operate over the 2,700-2,900 mc and 2,900-3,100 mc bands, respectively, at a peak power of 3 megawatts and a typical efficiency of 75%. Because no heater is required, these tubes are capable of exceptionally long life. RF gain is 8 db under rated conditions, and as high as 12 db at lower peak power outputs. Phase pushing figure is less than 0.5 degrees for a 1% variation of anode current.

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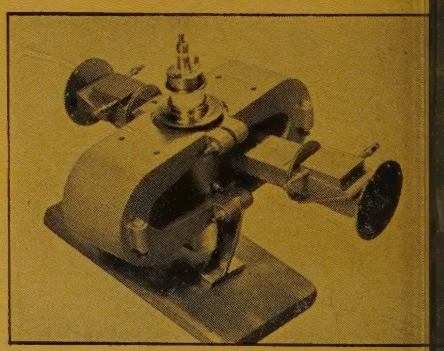

* * *

Compiled as a Raytheon service to the field, new Consolidated Data Booklet contains comprehensive information about principal unclassified magnetrons, klystrons, backward wave oscillators and special purpose tubes manufactured by Raytheon. Characteristics presented include maximum ratings, typical operating values, band or frequency ranges and other essential data for microwave engineers and purchasing departments.

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